AUGUST 2013

IN COMPLIANCE™

THE COMPLIANCE INFORMATION RESOURCE FOR ELECTRICAL ENGINEERS

Reaching for the Stars

from the Lens of a Telescope

PLUS

Diamond Jubilee
The 60th Anniversary of the Use of the 41 Inch Rod Antenna in Military EMI Testing

Are You Ready
for Entry to China?

Filter Connectors
from a 2013 Perspective

The Value
of Certification

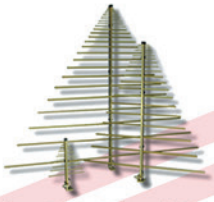
SPECIAL COVERAGE
2013
EMC Symposium

WHO SAYS YOU CAN'T HAVE IT ALL?

and with next-day, on-time delivery

Visit us at Booth 616
IEEE EMC 2013
Denver, CO

DRG Horns
170 MHz - 40 GHz
6 Models



Log Periodics
80 MHz - 7 GHz
13 Models

Preamplifiers
20 MHz - 40 GHz
8 Models

Low Loss Cables
DC - 40 GHz
4 Models

Biconicals
20 MHz - 330 MHz
5 Models

All in one small package

H-Field Rods
100 Hz - 30 MHz
4 Models

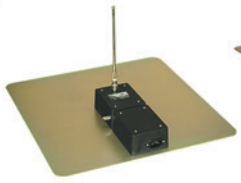
Probes
20 Hz - 1 GHz
16 Models

BiLogicals
25 MHz - 7 GHz
8 Models

Loops
20 Hz - 30 MHz
7 Models

Standard Gain Horns
1 GHz - 40 GHz
9 Models

Tripods and Accessories



Monopoles
100 Hz - 60 MHz
5 Models

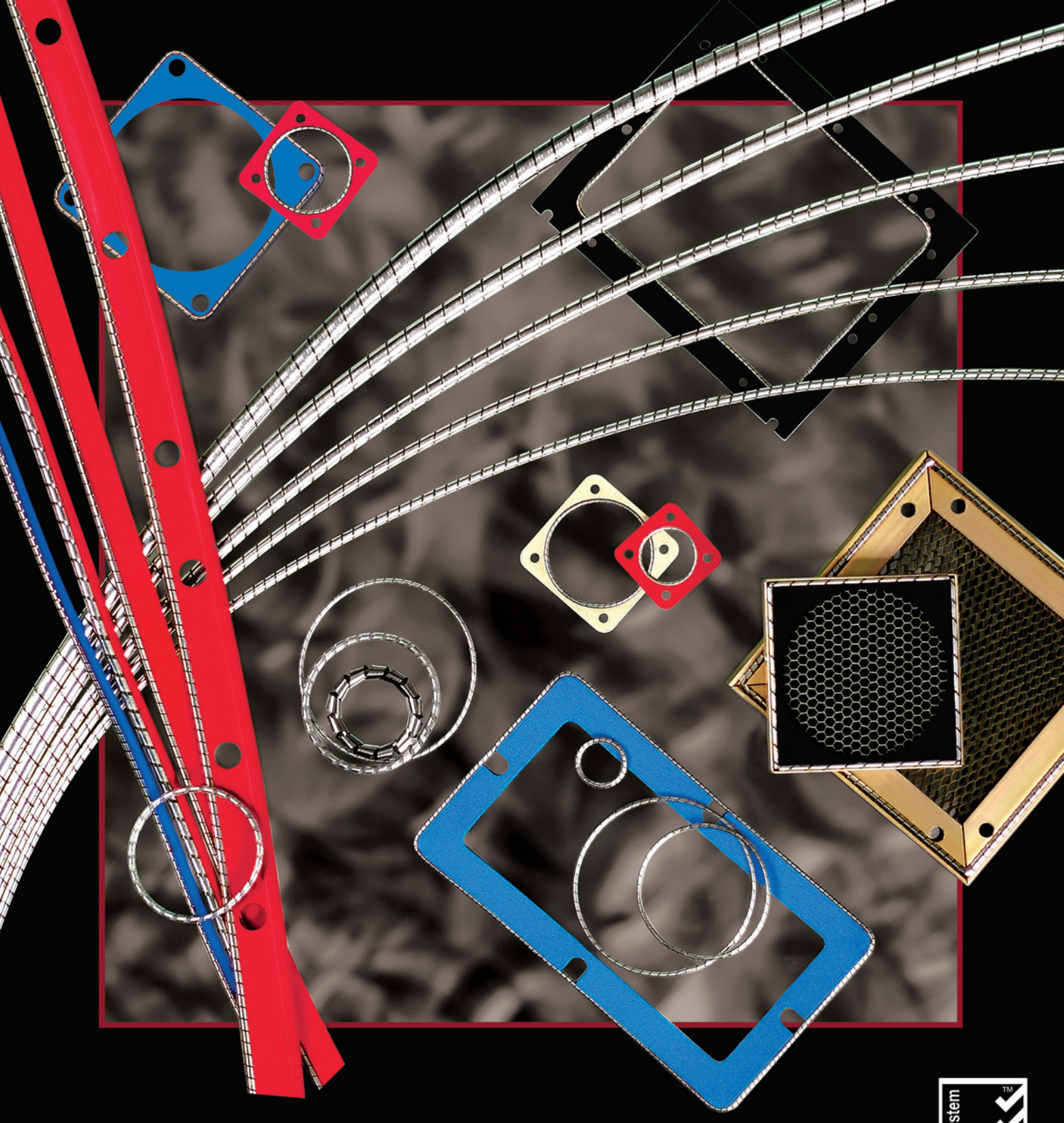
You Can Have It All when it comes to EMC/EMI testing. A.H. Systems is proud to bring you exciting new products, and many reliable favorites for your evaluation and compliance applications. Our antennas are unique and distinctive with broadband frequency ranges between 20 Hz up to 40 GHz. This enables us to specialize in various sales, rentals and, re-calibrations of test Antennas throughout the world. To view our products and get quick answers to your questions, access our comprehensive online catalog. Search for various information about product descriptions, typical AF plots, VSWR, power handling capabilities and links to product data sheets. Or simply request a catalog be sent to you. Not only have we been developing EMI Antennas for over 30 years, we also have organized worldwide sales representation. You can find your local knowledgeable representative in over 27 countries via our website. For quality products, excellent service and support with **next-day, on-time delivery.**

Antennas... **And Kits too.**

Innovation Quality Performance

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

A.H. Systems



The Inspiration in EMI Shielding

Visit our Website to request Free Samples, an EMI Educational DVD, Technical Assistance, & NEW EMI Shielding Catalog & Design Guide.

Certified System

ISO 9001
AS9100

Spira™

www.spira-emi.com

(818) 764-8222 info@spira-emi.com

All Products Made in the USA

Letter from the editor

Dear Readers,

This is a very special issue of *In Compliance*. Not only do we include an overview of this year's IEEE International Symposium on Electromagnetic Compatibility, we celebrate the 60th Anniversary of the Rod Antenna with author Ken Javor's Diamond Jubilee article (page 74) and in our lead article, *Reaching for the Stars from the Lens of a Telescope*, author Eddie Pavlu shares the development of his passion for astrophotography.

Over the years, we here at In Compliance have talked with many engineers in the compliance community and we've learned about a few hobbies that seem to stand out among the rest - photography is, undoubtedly, a favorite! We wanted to know more. What was it about photography that catches the eye (and the hearts) of so many engineers?

We invited Eddie Pavlu to share with In Compliance readers his story of exploration into deep space and the capture of the magnificent images held there. Eddie's story begins on page 54. On page 70 Eddie shares some of his favorite images – they are truly amazing. And there's more! You can also read about the creation of the author's home observatory at http://www.incompliancemag.com/pavlu_observatory.

Many of you will be heading to Denver, Colorado to attend this year's EMC Symposium to take advantage of the many networking and educational opportunities available. While there, be sure to stop by and visit us at booth 317 where we'll be outfitting subscribers with 2013's choice In Compliance t-shirt.

Until next time,

Lorie Nichols
Editor
editor@incompliancemag.com

IN COMPLIANCE

In Compliance Magazine
ISSN 1948-8254 (print)
ISSN 1948-8262 (online)
is published by

Same Page Publishing Inc.
531 King Street, Suite 5
Littleton, MA 01460-1279
tel: (978) 486-4684
fax: (978) 486-4691

editorial staff

editor/publisher Lorie Nichols
lorie.nichols@incompliancemag.com
(978) 873-7777

production director Erin Feeney
erin.feeney@incompliancemag.com
(978) 873-7756

contributing editor Mary Ann Kahl
maryann.kahl@incompliancemag.com

publishing staff

director of sales Sharon Smith
sharon.smith@incompliancemag.com
(978) 873-7722

national sales manager Shellie Johnson
shellie.johnson@incompliancemag.com
(404) 991-8695

marketing communications specialist Heather Stehman
heather.stehman@incompliancemag.com
(978) 873-7710

circulation manager Alexis Harrington
alexis.harrington@incompliancemag.com
(978) 873-7745

subscriptions

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

Subscriptions outside North America are $129 for 12 issues.
The digital edition is free.

Please contact our circulation department at circulation@incompliancemag.com

advertising

For information about advertising contact:
Sharon Smith at 978-873-7722
sharon.smith@incompliancemag.com

CONTENTS

August 2013
Volume 4 • Number 8

SPECIAL FEATURE:

DEPARTMENTS

FEATURES

Join us for this 3-Day Intensive Course

presented by renowned EMC expert Henry Ott

Electromagnetic Compatibility Engineering

a course in noise and interference control in electronic systems

September 24-26, 2013
University of Michigan-Dearborn
College of Engineering and Computer Science
Dearborn, MI

Presented by Henry Ott Consultants
in partnership with
IN COMPLIANCE

In this 3-day intensive course we'll cover practical aspects of noise and interference control in electronic systems and provide a working knowledge of EMC principles. Ideas are illustrated with examples of actual case histories and mathematic complexity is kept to a minimum. Participants will gain knowledge needed to design electronic equipment compatible with the electromagnetic environment and in compliance with national and international EMC regulations.

COURSE CONTENT

CABLING
Electric and magnetic field coupling, crosstalk. Cable types: coax, twisted pair and ribbon cables. Cable shielding and terminations.

GROUNDING PRINCIPLES
Why do we ground? Ground systems: single point, multipoint, hybrid. Ground loops. Return current paths, split reference planes. EMC grounding philosophy. AC power grounds.

DIGITAL LAYOUT & GROUNDING
Noise sources, PCB layout, power distribution, ground grids, characteristics of ground planes. Decoupling capacitors: value, placement, resonance and limitations.

HIGH SPEED DIGITAL DECOUPLING
Alternative decoupling methods, use of distributed decoupling capacitance, power supply isolation, effect of paralleling capacitors. Embedded PCB capacitance.

DIFFERENTIAL-MODE EMISSION
Radiated emission mechanisms. Fourier spectrum. Methods of controlling differential-mode emission. Clock dithering. Cancellation techniques.

COMMON-MODE FILTERING
Basic C-M filter theory. Filter source and load impedances. Single and multi-stage filters. Ferrite chokes versus shunt capacitors. Effectiveness of various filter configurations. Filter mounting and layout.

TRANSMISSION LINES
What is a transmission line? Transmission-line effects, transmission-line radiation, and matching. How currents flow on transmission lines. Series, shunt and AC terminations. Simulation.

MIXED SIGNAL PCBs
Defining the problem, A/D converter requirements, return current paths, split ground planes, PCB partitioning, bridges & moats, routing discipline.

RF & TRANSIENT IMMUNITY
RF immunity: circuits affected, PCB layout, audio rectification, RFI filters. Transient immunity: circuits affected, the three-prong approach, keeping transient energy out, protecting the sensitive devices, designing software/firmware for transient immunity.

CONDUCTED EMISSION
AC power line conducted emission models, switching power supplies, parasitic capacitance, layout. Common-mode and differential-mode conducted emission, common-mode chokes, saturation. Power line filters.

SHIELDING
Absorption and reflection loss. Seams, joints, gaskets, slot antennas, and multiple apertures. Waveguides below cutoff, conductive coatings. Cabinet and enclosure design.

EMC EXHIBITS AND EVENING RECEPTION: WEDNESDAY, SEPTEMBER 25, 2013
Exhibitors:for information contact Sharon Smith - e-mail: sharon.smith@incompliancemag.com or call (978) 873-7722

REGISTRATION

COURSE DATES/TIME: September 24-26, 2013
Tuesday and Thursday 8:30 a.m. to 4:30 p.m.
Wednesday 8:30 a.m. to 5:00 p.m.

COURSE LOCATION: University of Michigan-Dearborn, College of Engineering and Computer Science, 2050 Institute for Advanced Vehicle Systems, 4901 Evergreen Road, Dearborn, MI 48128

COURSE FEE: $1,495 ($1,295 until 8/16/2013). Fee includes notes, textbook*, breakfast, luncheon and beverage breaks. Payment required prior to course. Hotel accommodations are NOT included.

CANCELLATION POLICY: You may cancel your registration up to two weeks prior to the course and receive a full refund. For cancellations received after this time there will be a $100 cancellation fee, or you can send a substitute, or use the registration for a future course. No-shows will not receive a refund; however the seminar fee may be applied to a future course.

TO REGISTER: Call 973-992-1793, fax 973-533-1442 or mail the registration form.

HOTEL RESERVATIONS: Accommodations are available at the Adoba Hotel, 600 Town Center Drive, Dearborn, MI 48126-2793. For reservations call 313-592-3622. Room rates start at $99 per night plus tax. You must mention In Compliance Magazine when making reservations to get this special rate. The hotel is holding a limited block of rooms. You may also visit www.adobadearborn.com and use the group code of IMENC.

*Electromagnetic Compatibility Engineering, by Henry W. Ott

Who Should Attend

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

Feedback from recent participants

"This is really a fantastic course. Everything is very practical, and I have a much more intuitive feel for what is important in EMC and why."

"Very enjoyable presentation; passionate about subject, used good practical examples."

"Henry is the best in EMC."

"Probably the most useful technical seminar I have ever attended. Should have learned this 20 years ago."

"Thank You. Your work is very valuable and your presentation style is refreshing!!"

"Really happy I flew all the way here."

"Excellent course! Presented in a very understandable way, even for a mechanical engineer."

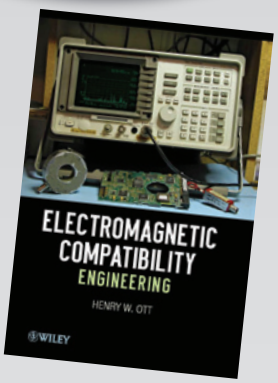
"Should be required training for all engineers."

"This is the best practical course available."

"An excellent seminar presented by a pragmatic, knowledgeable and entertaining teacher."

"This seminar exceeded by far my expectations, and my expectations were high already."

Includes Henry Ott's latest book!



HENRY OTT

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

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

Prior to starting his own consulting company, Mr. Ott was with AT&T Bell Laboratories, Whippany, NJ for 30 years, where he was a Distinguished Member of the Technical Staff and a consultant on EMC.

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

REGISTRATION FORM

Register by 8/16/13 and save $200!

ELECTROMAGNETIC COMPATIBILITY ENGINEERING

September 24 - 26, 2013

University of Michigan-Dearborn, College of Engineering and Computer Science

Dearborn, MI

Fee: ___ $1,495 ___ $1,295 until 8/16/13

Payment required prior to start of course.

Name: _____

Title: _____

Company: _____

Address: _____

City: _____ **State:** _____ **Zip:** _____

Office Phone: _____ **Fax:** _____ **E-Mail:** _____

PAYMENT METHOD

❍ Check ❍ P.O. ❍ AMEX

❍ Discover ❍ Visa ❍ MC

Card # _____

Exp date: _____ **Security Code:** _____

Signature: _____

Call 973-992-1793, fax to 973-533-1442 or mail registration form to: Henry Ott Consultants, 48 Baker Road, Livingston, NJ 07039-2502.
Make checks payable to Henry Ott Consultants.

News in Compliance

FCC News

FCC Extends Comment Deadline for Proposed U-NII Device Changes

The Federal Communications Commission (FCC) has extended the deadline for comments on its proposed expansion of spectrum available for so-called Unlicensed National Information Infrastructure (U-NII) devices.

U-NII devices are used for short range, high speed wireless connections, such as Wi-Fi enabled local area networks used in public places to connect smart phones, tablets and laptop computers to the broadband network. In a *Notice of Proposed Rulemaking* issued in February 2013, the Commission recommended making available up to an additional 195 megahertz of spectrum in the 5 GHz band for these devices to facilitate broader public access to higher speed broadband communications. In the same *Notice*, the Commission also proposed a more streamlined equipment authorization procedure for N-III devices.

The Commission has extended its comment deadline in connection with these proposed changes to July 24, 2013, following requests from the Wi-Fi Alliance and the IEEE 802 working group for additional time to provide more fully informed comments.

The complete text of the Commission's original *Notice* related to U-NII devices is available at incompliancemag.com/news/1308_01.

FCC Extends Comment Deadline on Recommendations for Improved Receiver Performance

The Federal Communications Commission (FCC) has extended the deadline for comments on its recent White Paper containing recommendations to improve receiver performance.

The FCC has announced that it has reached a settlement with two wireless carriers for failure to comply with the Commission's regulations regarding the provision of hearing aid-compatible (HAC) handsets.

The White Paper, "Interference Limits Policy—The use of harm claim thresholds to improve the interference tolerance of wireless systems," was issued by the FCC's Technical Advisory Council (TAC) in April 2013 to address the role of signal receivers as part of the overall effort to increase wireless spectrum utilization. Specifically, the Paper recommends that receiver technology should be included in spectrum policy efforts by establishing ceilings for interference limits, or "harm claim thresholds."

According to the White Paper, this approach would allow the Commission to offer guidance on optimizing receiver performance without dictating specific technical approaches or remedies.

The Commission has extended until July 22, 2013 its comment deadline in connection with these recommendations, following requests from the Consumer Electronics Association, the National Association of Broadcasters and the GPS Innovation Alliance to further review the contents and policy proposals detailed in the White Paper.

The complete text of the Commission's TAC white paper is available at incompliancemag.com/news/1308_02.

FCC Enforces HAC Carrier Requirements

The U.S. Federal Communications Commission (FCC) has announced that it has reached a settlement with two wireless carriers for failure to comply with the Commission's regulations regarding the provision of hearing aid-compatible (HAC) handsets.

In the Commission's recent settlement, Airadigm Communications and TeleGuam Holdings have agreed to voluntary payments to the U.S. Treasury totaling more than $500,000. The wireless carriers also agreed to implement robust programs to ensure future compliance with the Commission's requirements, including new operating procedures, employee training programs, and mandatory reporting to the Commission.

The FCC requires that wireless service providers offer a minimum number of HAC handsets, so that hearing-impaired consumers are able to take advantage of wireless communications technology. Failure to comply with the FCC's requirements can result in monetary forfeitures starting at $15,000 per violation for each month during a year in which the provider failed to provide the requisite number of HAC wireless handsets. Forfeiture amounts of as much as $150,000 per violation or for each day of a continuing violation, up to a maximum of $1,500,000 for a single violation, are permissible under the Commission's rules.

Lost Time Is Lost Money

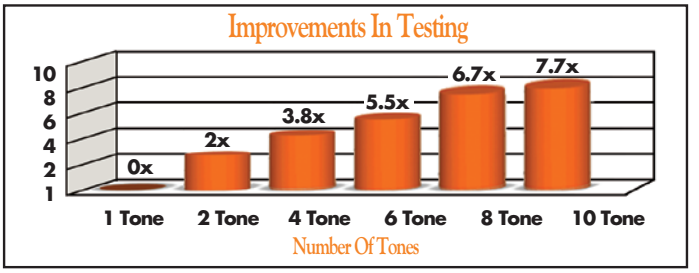
Radiated Immunity Testing Reduced From Days To Hours...

Using Our NEW MultiStar Multi-Tone Tester

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

Maximize your efforts during dwell time by testing multiple frequencies simultaneously, which increases testing speed, gets your product to market faster and eliminates costly chamber bottlenecks.

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



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

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

Visit us at www.arworld.us/MultiTone or call 215-723-8181.

Come See Us at EMC 2013
Colorado Convention Center, Denver, Colorado, August 6-8, 2013 – Booth 507

ISO 9001:2008 Certified

rf/microwave instrumentation

Other ar divisions: modular rf • receiver systems • ar europe

USA 215-723-8181. For an applications engineer, call 800-933-8181.
In Europe, call ar United Kingdom +44 1908 282766 • ar France +33 147 917530 • ar GmbH +49 6101 80270-0 • ar Benelux +31 172 423000

www.arworld.us

News in Compliance

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 June 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/1308_03.

EU Publishes List of Energy Efficiency Standards for Dishwashers

The Commission of the European Union (EU) has published an updated list of standards that can be used to demonstrate conformity with its Regulation regarding the ecodesign of household dishwashers.

The ecodesign Regulation for household dishwashers was originally published in November 2010 in the *Official Journal of the European Union*, is considered an implementation measure under the EU's Eco-Design Directive, 2009/125/EC. The requirements are based on the unit's Energy Efficiency Index, its Cleaning Efficiency Index, and its Drying Efficiency Index, which are calculated following the methods described in Annex II of the regulation.

The updated list of Cenelec standards was published in June 2013 in the *Official Journal of the European Union,* and replaces all previously published standards lists for the Regulation. The list of standards is available at incompliancemag.com/news/1308_04.

EU Sets Eco-Design Requirements for Computers

The Commission of the European Union (EU) has issued a Regulation implementing new energy efficiency requirements for computers and computer servers.

The Regulation, which was published in June 2013 in the *Official Journal of the European Union*, is considered an implementation measure under the EU's Eco-Design Directive, 2009/125/EC. That directive gives the Commission the authority to establish minimum efficiency standards for those "energy-related products representing significant volume of sales and trade, having significant environmental impact and presenting significant potential for improvement in terms of their environmental impact without entailing excessive costs."

The new energy efficiency requirements for computers and computer servers are extensively detailed in Annex II of the Regulation. Requirements for a power management function and the maximum allowable power demand in the lowest power state are now in effect, while compliance with most of the remaining requirements must be achieved by July 1, 2014. Annex III of the Regulation details the procedure to be used by authorities in EU member states for verifying compliance with the Regulation's requirements.

The complete text of the Commission's Regulation regarding the eco-design of computers and computer servers is available at incompliancemag.com/news/1308_05.

The Commission of the European Union (EU) has updated standards lists for the Personal Protective Equipment Directory. The EU has also released a list of energy efficiency standards for dishwashers, as well as setting eco-design requirements for computers.

CPSC News

Executive Receives Prison Sentence for Importing Banned Products

A U.S. District Court has sentenced an import company executive to 22 months in a federal prison for smuggling banned children's products that contained lead and small parts into the U.S.

The executive, Hung Lam, president of LM Import-Export, Inc. of Miami, FL also received a sentence of three years of supervised release following his incarceration and was ordered to pay a $10,000 fine in connection with the conviction. In addition, the Court issued a forfeiture order of $862,500 against Lam and his co-defendant Isabella Kit Yeung.

According to a press release issued by the United States Attorney's Office for the Southern District of Florida, Lam and his company conspired to sell and distributed hazardous children's products incorporating lead and small parts imported from China from about April 2000 through May 2011. Such products are banned under the U.S. Consumer Product Safety Act and the Federal Hazardous Substances Act. Lam allegedly succeeded in bringing these banned products into the U.S. by making false statements on custom declaration forms.

More details about the Court's ruling are available at incompliancemag.com/news/1308_06.

Best Buy Recalls Mac Book Batteries

Retailer Best Buy has initiated a recall of about 5100 lithium-ion batteries manufactured in China and sold as replacement batteries for Apple MacBook Pro notebook computers.

According to Best Buy, the recalled batteries can catch fire while charging, posing a fire and burn hazard to consumers. The company says that it has received 13 separate reports of the battery catching fire, including one report of a consumer receiving a serious leg burn.

The recalled batteries were sold through Bestbuy.com and Partstore.com, or shipped to customers through Best Buy's Geek Squad Protection program, between September 2008 and June 2012, for about $50.

Additional information about this recall is available at incompliancemag.com/news/1308_07.

Best Buy has issued a recall for Mac Book batteries due to the batteries catching fire while charging.

Horizon Hobby, Inc. is recalling 7.4 volt batteries used to power the company's line of remote control vehicles.

News in Compliance

CPSC News

Batteries Recalled Due to Fire Hazard

Horizon Hobby, Inc. of Champaign, IL has recalled 7.4 volt batteries manufactured in China and used to power the company's line of remote control vehicles.

According to the company, the positive and negative leads of the recalled batteries are incorrectly wired to the battery connector. As a result, using or charging the battery can cause it to overheat, posing a fire or burn hazard to consumers. Horizon Hobby says that is has not received any reports of incidents or injuries, but has initiated the recall to prevent future incidents.

The recalled batteries were sold through hobby stores nationwide and at www.horizonhobby.com from December 2012 through April 2013 for about $20.

Additional details about this recall are available at incompliancemag.com/news/1308_08.

You Can't Make This Stuff Up

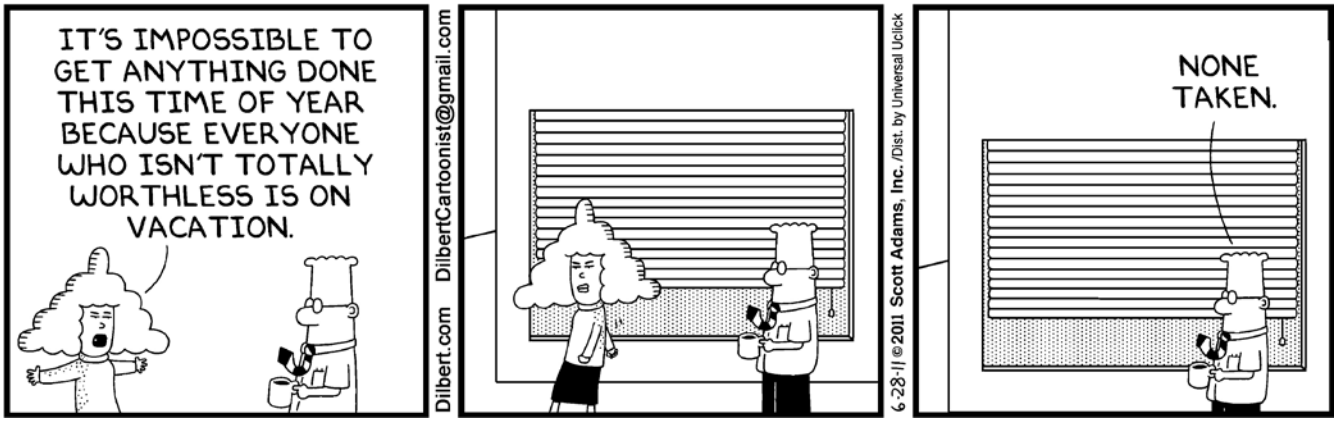
Man Transfers Fortune While Asleep at Keyboard (From our "You Can't Make This Stuff Up" file)

While a daytime nap may refresh your energy and spirits, be sure not to doze off on your keyboard.

According to a report from Agence France Presse, a German bank employee briefly fell asleep while entering a funds transfer on his computer keyboard. Unfortunately, instead of transferring 62.4 euros, his sleepy finger stuck the number 2 key in position, resulting in an actual transfer of 222,222,222.22 euros.

The huge transfer was later caught and corrected by the bank, but not until after the bank employee's colleague failed to catch the mistake when verifying the order. The colleague was terminated for the oversight, but a Hessen labor court later order that the colleague be reinstated in his job.

Instead of transferring 62.4 euros, a sleepy German bank employee's finger stuck the number 2 key in position, resulting in an actual transfer of 222,222,222.22 euros.



The most comprehensive line of RF cable assembly solutions for EMC testing

RF cable assembly and connector solutions for EMC immunity and emission compliance testing

TRU Corporation offers a full line of RF cable assembly solutions ideally suited for EMC immunity and emission testing. Our TRUflex™ PWR series with quick-disconnect interfaces provide maximum power handling and mating efficiency for immunity testing requirements while our TRUcore™ series provides low loss and broadband frequency up to 50 Ghz for emission applications.

Visit us at EMC 2013 • Booth 924

Scan to view our complete EMC product brochure

TRU Corporation
Peabody, MA 01960 USA
1 800 262-9878
(1 800 COAX-TRU)
978 532-0775
trucorporation.com

YES IT'S TRU®

EXPERIENCE. TRU INNOVATION.

All chamber photos courtesy of ETS-Lindgren Inc

MR. Static

Are Ions Good for You?

Mr. Static explores the reputed physiological effects of ions.

BY NIELS JONASSEN, sponsored by the ESD Association

About a hundred years ago, it appeared as if all the important discoveries in physics happened almost simultaneously. For example, Wilhelm Röntgen discovered and developed x-rays, and Henri Becquerel and the Curies discovered radioactivity. It was soon realized that both phenomena had effects that could be put to very important use in industry, medicine, and other scientific fields.

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

However, the discoverers themselves were not aware that exposure to these phenomena could pose a health hazard. Röntgen is known to have looked directly into an x-ray beam to determine whether it had any effect on the eye, Becquerel always wore a lump of pitchblende in his waistcoat pocket, and Marie Curie developed radiation damage to her hands from handling radium.

Although x-rays and radioactivity have many similarities, they are obviously very different in nature. X-rays, being associated with accelerated electrons impinging on certain metals in vacuum, are not natural phenomena, whereas radioactive processes have taken place since the first day.

It is also interesting that the common by-products (i.e., atmospheric ions or air ions) of both processes when taking place in atmospheric air were not recognized until about the same time as the discoveries of x-rays and radioactivity. It could be speculated that the cause must be known before the effect can be discovered, but this is not so. The existence of atmospheric ions could very well have been predicted a century earlier. In 1796, Coulomb had already observed that an insulated charged body would gradually lose its charge when exposed to atmospheric air. However, it was not until 1899 that Elster and Geitel and, almost simultaneously and independently, C.T.R. Wilson demonstrated the existence of mobile charge carriers in air and rightfully ascribed it as the result of radioactive decay of mostly airborne nuclides such as radon and its short-lived daughters.

The nature of air ions has been discussed at length several times in this magazine, so let it suffice to state a few simple facts.[1, 2, 3] Air ions are not charged molecules or atoms. They are clusters of mostly water molecules (say 12–14) around an oxygen or nitrogen molecule that has lost an electron (i.e., a positive ion), or 8–10 water molecules around an oxygen molecule that has gained an extra electron (i.e., a negative ion).

All air ions are created equal. There is no difference between the ions produced by radioactive decay of airborne materials or by cosmic rays, and the ions produced in a technical ionization system by accelerating incidental electrons to sufficiently high energies. This technical method of ionization is again, in principle, identical to what happens when the field from a thundercloud induces corona discharges from the tips of leaves or from lightning rods.

It should be stressed that ions are always created in pairs—a positive and a negative ion. In unipolar field ionizers, one polarity is automatically held back, so it appears as if only positive or negative ions are produced, but that is not so.

emtest
the benchmark for emc

WELCOME TO THE UNITED STATES OF EMC

READY FOR HYBRID AND E-VEHICLES

VISIT US AT:
2013 IEEE
INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY (EMC 2013)
BOOTH 521
5 AUG — 9 AUG 2013

THE STATE OF IEC

UCS 500N7 Immunity Test Simulator as per IEC, ANSI/IEEE, Bellcore/Telcordia
› Surge & Telecom pulse 7 kV
› Burst, Ringwave, Dips/Interruptions up to 300 V
› Extensive range of 3-phase coupling filters and accessories

THE STATE OF AIRCRAFT & MILITARY

NetWave, programmable AC/DC source up to 60 kVA
› DO-160, MIL-STD 704, Boeing, Airbus
› Recovery function

THE STATE OF ISO

Automotive Test Simulators for any international and worldwide car manufacturer standards
› ISO, SAE, Chrysler, Ford, GM, Toyota ...

Your partner for all your needs throughout NORTH AMERICA:
EM TEST USA › 9250 Brown Deer Road › San Diego, CA 92121 › USA
› Phone + 1 (603) 396 2680 › E-mail products.emtest@ametek.com

AMETEK®

www.emtest.com

MR. Static

One of the oldest claims concerning the effect of ions is that air rich in negative ions is fresh and that air rich in positive ions is stuffy.

Ions do not live forever. They recombine with oppositely charged ions, they combine with aerosol particles, and they plate out on surfaces. Therefore, the reason for a more or less constant ion concentration of some hundred ions of each polarity per cubic centimeter (at sea level) is the constant production of maybe 5–10 ion pairs per cubic centimeter per second caused by natural radiation. So to keep a high ion concentration in a given volume, ions have to be constantly produced.

Air ions have a very important role to play in industry, namely that of neutralizing charges on insulators. In fact, the use of a bipolar mix of air ions is the only way by which the field from a charged insulator can be neutralized. The charge can never be removed, but the field from the charge can be neutralized, and that is just as good. As that problem has already been treated in detail, this article concentrates on the claims of direct or indirect effects of air ions on human beings.

Almost from the very first detection of air ions, there has been speculation about possible hygienic, physiological, or other types of effects. The first paper may have appeared as early as 1923. Very few, if any, of these first papers deserve the designation of *scientific papers*, which should only deal with properly described and properly conducted investigations. Almost all reported investigations were purely anecdotal. In my opinion, one of the reasons for this was that usually the investigations were carried out by physicians and other laypeople without the guidance of physicists with a proper knowledge of atmospheric electricity.

For example, in the 1930s, it was rather common in Germany to treat a variety of ailments, such as asthma, bronchitis, and other airways-related problems, by letting the patients (apparently) inhale negative ions. Some of the administrants of these treatments, usually medical practitioners, reported rather astonishing results. At a certain point in these experiments, somebody had the good sense to ask a real expert to examine the ionizers to find out what they were actually doing. The all-time-ever expert on atmospheric electricity, Hans Israël, agreed to do this.[4] Years later, I heard Hans Israël summarize his investigation. It appeared that the ionizers used by some of the doctors with the most beneficial results did not even contain a high-voltage supply; that is, they did not produce ions at all.

THE NEGATIVE-ION MYTH

The previous story is a good example of a negative-ion myth. Repeatedly, it has been reported that negative ions are good and that positive ions are bad, usually with little if any scientifically rigorous documentation.

One of the oldest claims concerning the effect of ions is that air rich in negative ions is fresh and that air rich in positive ions is stuffy. Of course, it is difficult to prove or disprove such statements, as freshness and stuffiness are subjective quantities for which there is no physical method of measurement. Therefore, let us be subjective. Let us assume that most people will agree that the air at a mountaintop deserves to be called fresh. Now, it just so happens that this air is rich in positive ions, the concentration being maybe 3–4 times greater than at sea level. The freshness and the positive ions have nothing to do with each other. The freshness could be caused by the air being unpolluted and cool, and the high positive-ion concentration is simply a result of the electrode effect.

Let us also assume that most people will find that during a thunderstorm (before the rain sets in) the air may be considered less than fresh, maybe even stuffy. This same air is rich in negative ions. The stuffiness might be explained by high humidity and other thermophysical factors, and the high negative-ion concentration is simply an effect of the strong negative field from the base of the thundercloud to the ground.

Another example of the negative-ion myth concerns the effects of ions on the cilia in the respiratory tract. From 1957 through 1963, a series of papers were published by Krueger et al., who suggested that air with an excess of positive ions caused a deceleration of cilia activity and of the rate of mucus flow, whereas air with an excess of negative ions produced changes in the opposite direction and reversed the effects of positive ions.[5,6] In other words, exposure to negative ions would increase the rate with which the airways were cleared.

Although other researchers failed to show any effects of unipolar ionized air on cilia frequency and mucus flow, the papers of Krueger et al. were widely quoted; even today, there are still positive references to their work. This is in spite of the fact that, in 1971, Andersen's book Mucociliary Function in Trachea Exposed to Ionized and Non-Ionized Air demonstrated without

any doubt that the claimed effects do not exist.[7] Andersen gave a very thorough and sober evaluation of all the previous work and pointed out a series of experimental shortcomings that made any conclusion drawn from the results dubious. Andersen also conducted a large experimental study under carefully controlled conditions (thermodynamic, aerodynamic, and electrical) and using modern equipment. He demonstrated that there was no relationship between ion concentration (of either polarity) and cilia frequency. His conclusion was as follows:

It is concluded that—the application of unipolar or bipolar ionized air in the therapy of diseases in the airways, and active control of ion concentrations in homes and places of work etc. for prophylactic reasons must be considered without any experimental-physiological basis.

THE ION-BALANCE MYTH

The ion-balance myth is a special version of the negative-ion myth. The concept of ion balance is not really defined in atmospheric electricity, but it is probably supposed to mean the ratio between the concentrations of negative and positive ions. In a closed room, it is obviously possible to control this ratio by producing an excess of ions of one polarity. However, this is not what is normally meant when references are made to changes in ion balance. It is often claimed that certain procedures or even just certain materials will selectively remove one polarity of ions. Over the years, it has been claimed time and time again that if the ions removed were the negative ions, the result would be a bad ion balance.

In this context, we are talking about naturally occurring ions, that is, ions produced primarily by the decay of airborne radioactive materials. As already mentioned, ions are always produced in pairs; therefore, the production rates for positive and negative atmospheric ions are identical. In the free lower atmosphere, a state of equilibrium will be reached at which the constant production of ions is balanced by positive and negative ions recombining with each other, combining with aerosol particles, or diffusing to ground. The result will be a state with a positive-ion concentration maybe 20–25% higher than the negative one. The difference is caused

MR. Static

People in industry, and especially those in the world of electronics, know what it means when a flow of ionized air is directed toward a charged insulator.

by the positive ions having a somewhat lower mobility than do negative ions ($1.4 \bullet 10^{-4}$ $m^2V^{-1}s^{-1}$ and $1.8 \bullet 10^{-4}$ $m^2V^{-1}s^{-1}$, respectively). Positive ions therefore also have a lower diffusivity, and this is balanced by a higher concentration of positive ions so that the actual removal rate by diffusion is the same for both positive and negative ions.

The actual values of the ion concentrations depend strongly on the concentration of aerosols or pollutants. In relatively clean air, the concentrations of the ions may be in the hundreds (per cubic centimeter), in highly polluted air, they may be 10 times as low. But the important fact is that the ratio, the ion balance, is almost the same, about 1.2–1.3.

A high level of pollution will turn most of the ions into charged particles, or heavy ions, but with no preference for either polarity. Since the 1930s, it has been known that the attachment coefficients for negative and positive ions attaching with aerosol particles are almost the same, resulting in a population of aerosol particles divided more or less equally between negative, positive, and neutral particles. This is true with moderate pollution levels. With very high aerosol concentrations, there are not enough ions to charge the aerosol particles, and the neutral particles will dominate.

Evil Winds Are Rich in Positive Ions

It seems reasonably well documented that the hot winds like the Föhn, the Santa Ana, the sirocco, and so forth have a detrimental influence on people's well-being. To explain the special properties of these phenomena, it has often been postulated that the winds, maybe especially the Föhn Alp wind, are rich in positive ions and therefore, according to the negative-ion myth, will feel stuffy and unpleasant. I have never been able to find any hint of a trustworthy theory explaining how a unipolar ionization of the air mass could take place, let alone explain how the charge could be carried hundreds of miles over the mountains without dissipating. I have also not seen any proper scientific papers demonstrating the excess of positive ions in these winds.

Building Materials May Ruin the Ion Balance

Around 1960, a peculiar campaign started in several European countries. The campaign was based on the negative-ion myth. It was claimed that floor coverings of vinyl tiles would ruin the ion balance, meaning that they would create an excess of positive ions, whereas linoleum floors would allegedly leave the ion ratio untouched. No scientific proof for the claim and certainly no measurements were offered, but not a week went by without statements from newspapers, magazines, radio, or television about the harmful effects of vinyl tiles.

A major Danish company that was economically hurt by the campaign asked if the problem could be investigated. I conducted a series of ion-concentration measurements in rooms that were as identical as possible, except that half of the rooms tested had linoleum floors and the other half had vinyl tiles. No significant difference between the two types of rooms could be detected with respect to either the absolute values of the ion concentrations or the ion ratio.

Sick Building Syndrome and the Ion Balance

Over the past 40 years, the interest in the indoor climate has been steadily growing, and in the 1970s, the concept of sick buildings emerged. It appeared that many people felt uncomfortable and maybe even sick when working in certain buildings, especially modern buildings. The symptoms were usually vague, such as headaches, eczema, dry skin, problems with breathing, and so forth.

Many suggestions for the causes were proposed, including mold fungi and dust mites, but both of these causes are connected with inefficient ventilation. It was also suggested that the cause could be a bad ion balance. Many well-controlled experiments were performed in many different types of buildings. None of the experiments showed any significant deviations from the normal ion-concentration values. Note that there probably is such a thing as a sick building, but it apparently has nothing to do with atmospheric ions.

Positive Ions and Pollution

A peculiar variation of the ion-balance myth has emerged over the past decade. It states that positive ions and air pollution are intimately related; that is, positive ions will preferentially attach to airborne particulates. First of all, this is not true. As already mentioned, the attachment coefficients are very similar for both positive and negative ions. Second, this myth is taken as another proof that positive ions are harmful

because they attach themselves to pollutants. If this really were the case, it would mean that polluted air would have an excess of negative ions, as the pollutants would swallow positive ions. However, as already stated, this is not so. Polluted air may have low concentrations of both positive and negative ions.

The examples treated above illustrate rather well a statement made as early as 1985 by Reinhold Reiter, a recognized expert on atmospheric electricity: "Nearly all relevant assertations about harmful or beneficial effects of small ions fail to realize the fundamental elements of atmospheric electricity."[8]

ARE IONS GOOD FOR YOU?

So far, the question posed in the title of this article has not really been answered. Instead, discussion has focused on some physical facts and has tried to quench some unfounded myths. Before trying to answer the question, it is important to look at what ions can actually do. Atmospheric ions consist of a nitrogen or oxygen molecule, a few water molecules, and an elementary charge. Human beings are constantly exposed to a mixture of nitrogen, oxygen, and water vapor, so what difference would it make if there were also a positive or negative charge involved?

People in industry, and especially those in the world of electronics, know what it means when a flow of ionized air is directed toward a charged insulator. If the flow is properly balanced, the charge on the insulator can be neutralized because the ions are able to give off their charge. It is the only way that a charged insulator can ever be neutralized.

But what does this have to do with human beings? If a balanced flow of ionized air is directed toward an area of exposed skin, the positive and negative ions will be neutralized when plating out very close to each other, and the result may be some very weak currents on the outer layer of the skin. However, it is a completely different story if a unipolar (say negatively ionized) airflow is used instead. If the person is not grounded, the body will acquire a gradually increasing negative voltage until a discharge, usually a spark, takes place or until the unavoidable leakage current balances the ion current.

The case becomes much more interesting if the person is grounded. Let us suppose that the person is placed on an insulative sheet and that a grounded wrist strap is attached to the right wrist. Now, if a unipolar (say negatively ionized) airflow is directed toward the person's exposed back, the ions will plate out on the skin and be neutralized, and their charge will run through the body to the wrist strap. If this process has an effect, it would not be because of the ions per se. The ions have only served as carriers of the charge to the body. So the questions are "can these currents have any effects?" and "what kind of paths do the currents follow?" I am far from sure that I can answer these questions, but I can tell a story.

UNIPOLAR IONIZED AIR

A few years ago, I was contacted by a Danish architect; let us call him Mr. W. He was very interested in indoor climate and wanted to learn more about ions and their effects on people. Of course, I told him that ions had

MR. Static

no (direct) effect on people, but sure, I could teach him something about ionizers for air-cleaning purposes and for neutralizing charges on insulators.

Mr. W believed in the healing effects of (negative) ions. He used unipolar ionizers for treating patients suffering from various ailments and reported surprisingly positive results. I insisted that it was not the ions but their charge that was responsible for any effects. After some pilot laboratory experiments, it was demonstrated that positive and negative ions were equally effective. The flow of unipolar ionized air seemed to be especially effective in healing sores and wounds and in reducing (and not only temporarily) pains and side effects in, for example, cancer patients undergoing chemotherapy or radiation treatment. Mr. W also had some ideas that the method actually was a kind of acupuncture, but in any event, it was definitely an alternative method of treatment.

In the Western world, or at least in Denmark, the established medical society frowns on anything alternative, especially if it contains elements of sciences of which the established medical society has no knowledge and experience—such as physics. So there was no way that Mr. W could have a clinical test of his method performed in Denmark under proper medical supervision. However, in other parts of the world, the attitude to alternative treatment methods is quite different.

At the prestigious Chulalongkorn University Hospital in Bangkok, where acupuncture is a recognized specialty, the chief oncologist, Kris Chatamra, had heard about Mr. W's results and offered to set up a small pilot project as a forerunner for a proper clinical test. The pilot project was conducted in June 2002. Chatamra had chosen four very sick patients for the test: three cancer cases (considered terminally ill) and one patient with a chronic infection (diabetes related) on one foot. All four patients were in severe pain and required regular and strong analgesia.

The patient to be treated was placed on an insulative sheet on a cot, and a wrist or ankle strap was attached to the patient. A flow of unipolar ionized air was directed toward a selected exposed part of the patient's skin. The strap connected the patient to the ionizing unit through a feedback system, which monitored the ion flow and the total dose. The current to the patient was in the order of μA, and the exposure time was typically 90 minutes. The length of the trial was 10 days. The patients were fully assessed prior to the trial and also assessed daily during the trial by a specialist nurse. Pain assessment was conducted by patient scoring and by the amount of analgesia required daily.

At the end of the pilot project, Chatamra concluded:

The results are encouraging: All patients required less analgesia (one patient actually stopped taking it altogether). The chronic wound also showed accelerated healing, and the patient is now discharged from the surgical unit. None of the patients suffered any complications.

This was a very small project. It did not prove anything, scientifically speaking. But as Chatamra says, the results are encouraging. A proper clinical test with all the necessary precautions, such as double-blind testing and the use of a control group, is planned.

My role in the pilot project, and maybe in the (hopefully upcoming) clinical test, has merely been that of a physics consultant and observer—an observer who has gradually lost his belief that ions have no effect on human beings. However, to quote Luke 15:7, "There will be more rejoicing in heaven over one sinner who repents." Still, the negative-ion myth and the ion-balance myth are nothing but that, myths. IN

REFERENCES

1. Niels Jonassen, "Ions" in Mr. Static, *Compliance Engineering* 16, no. 3 (1999): 24–28.
2. Niels Jonassen, "Neutralization of Static Charges by Air Ions: Part I, Theory" in Mr. Static, *Compliance Engineering* 19, no. 2 (2002): 28–31.
3. Niels Jonassen, "Neutralization of Static Charges by Air Ions: Part II, Experimental Results" in Mr. Static, *Compliance Engineering* 19, no. 4 (2002): 22–27.
4. H Israël, *Atmosphärische Elektrizität* (Leipzig, Germany: Springer Akademische Verlagsgesellschaft, 1957).
5. AP Krueger and RF Smith, *Proceedings of the Society of Experimental Biology* 96 (1957): 807–809.
6. AP Krueger, PC Andriese, and S Kotaka, *International Journal of Biometeorology* 7 (1963): 3–16.
7. I Andersen, *Mucociliary Function in Trachea Exposed to Ionized and Non-Ionized Air* (Aarhus, Denmark: Akademisk Boghandel, 1971).
8. RJ Reiter, *Journal of Geophysical Research* 90 (1985): 5936–5944.

(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.

Meet the Newest Member To Our Family

IMU3000

Touch the Future

- **Electro Static Discharge (ESD)** IEC 61000-4-2 / ANSI C62.41
- **EFT/Burst** IEC 61000-4-4, ANSI C62.41
- **Combination Wave (CWG)** IEC 61000-4-5 / ANSI C62.41
- **10/700µs Telecom Impulse** IEC 61000-4-5 + ITU K.20/21/44
- **Magnetic Field AC** IEC 61000-4-8
- **Magnetic Field Impulse** IEC 61000-4-9
- **AC DIPS / Interrupt** IEC 61000-4-11
- **Ringwave** IEC 61000-4-12 / ANSI C62.41
- **Common Mode (CM)** IEC 61000-4-16
- **Differential Mode** IEC 61000-4-19
- **DC DIPS** IEC 61000-4-29

Impulse Modular Unit

Just like our TRA3000 generator, the IMU3000 can be upgraded in the field.

- 7” Color Touch Panel
- Create and Link tests from the front panel and get full reports
- Each module comes calibrated and ready to test
- EFT Choose 5kV or 6kV
- SURGE, RINGWAVE and 10/700µs Choose 6.6kV or 8.1kV
- TEMA3000 Software is even modular, purchase what you need
  - Updates are FREE
- Large range of accessories, for all applications

Your Partner for EMC Solutions

EMC - PARTNER
www.emc-partner.com

emcsales@hvtechnologies.com
703-365-2330

HV TECHNOLOGIES, Inc.
www.hvtechnologies.com

EMC Education

The View from the Chalkboard

BY MARK STEFFKA

For this month's edition of the "View from The Chalkboard" I am focusing on an amazing progression that one university (Grand Valley State University in Grand Rapids, Michigan) was able to do in a short time in the establishment of an EMC curriculum. The person behind this work is Dr. Bogdan Adamczyk, who is both the Director of the GVSU EMC Center and the Electrical Engineering Department Chair.

Dr. Bogdan Adamczyk
adamczyb@gvsu.edu

Dr. Adamczyk and myself recently had a discussion about how the EMC Center came to be, what its role is in serving the needs of both the students and local industry, and most importantly the "lessons learned" in going from no EMC curriculum to a valuable center of EMC knowledge and *EMC precompliance testing* in Western Michigan.

Dr. Adamczyk has a unique background in both academia and industry which gave him the perspective needed to realize how a university – industry partnership in EMC could be developed and successfully implemented.

Dr. Adamczyk and I hope you find his comments and insight useful in your work in EMC education!

Mark Steffka: What does your university offer for EMC education?

Dr. Adamczyk: EMC education at GVSU serves two different populations: university-enrolled students and the local EMC professionals. For the GVSU students, the following four semester-long courses are available: junior-level *Applied Electromagnetics*, senior-level *Electromagnetic Compatibility*, graduate-level *Printed Circuit Board Design and EMC*, and *EMC Special Topics*.

For the local EMC practitioners we offer the following four courses: *Math and Circuits Foundations of EMC, Electromagnetics Foundations of EMC, EM Waves, Transmission Lines and Antennas Foundations of EMC, EMC Special Topics*.

Mark Steffka: What role does the EMC Center play in supporting the EMC education and local industry?

Dr. Adamczyk: The EMC Center provides two types of services: EMC education and EMC precompliance testing. In addition to the EMC courses already mentioned, the EMC Center supports senior and graduate projects, and in the near future will provide internship for GVSU students.

For the local industry, the EMC Center offers EMC precompliance testing and design support. There is a tremendous

Dr. Adamczyk has a unique background in both academia and industry which gave him the perspective needed to realize how a university – industry partnership in EMC could be developed and successfully implemented.

need in the local industry for a timely, affordable and easily accessible EMC precompliance testing facility.

These two services can be related. Many tests performed at the EMC Center find their way into the EMC course content, laboratory exercises and demonstrations for the GVSU students. Many course design projects are tested at the EMC Center providing the students with the exposure to the current EMC regulations, testing equipment and procedures.

EMC Center Seminar Room

Mark Steffka: What prompted you to become involved in EMC?

Dr. Adamczyk: It's really a result of the desire to make the university courses relevant to today's industry needs and to reflect current engineering practices. The process first began in 2005, when I attended the IEEE EMC Symposium in Chicago. As you know, that is when I first met you and Dr. Clayton Paul. Through the encouragement of both of you, I then applied for the IEEE EMC Society Education Grant (now known as the John Howard Memorial Grant) and was fortunate to subsequently receive the grant to establish an EMC course.

Mark Steffka: How did you continue the process after receiving the grant?

Dr. Adamczyk: After receiving the grant, in 2007 you recall that I spent one day per week attending your EMC courses and undergraduate EMC lab facilities at the *University of Michigan's* Dearborn campus. Then with that background, I started working with a local EMC lab in an industry setting. It was there that I developed ideas on how my university could have formal courses for students as well as provide EMC education for industry engineers. One of the key items I observed was that it was very difficult for working engineers to become proficient in EMC, since without a local university curriculum much of the EMC education they received was very focused and sporadic (such as attending the EMC Symposium once a

EMC Education

In addition to doing well in their academic studies, students should always strive to be involved in professional societies and maintain a network of colleagues. This is key to the engineering practice!

year). Although that wasn't wrong – it just was not efficient. I then realized that the key was to provide continuous "after work hours" education at a measured pace. It was at that point I began partnering with local industry to provide that type of education. That approach proved to be a success and has become a foundation of the EMC Center offerings'.

Mark Steffka: Can you tell me about the physical location of the EMC Center and other initiatives that you have been involved in?

Dr. Adamczyk: Two years ago, it turned out that there was warehouse facility that was owned by the university that I realized could be re-purposed and put to use as the formal location of the EMC Center.

In addition we have established a local IEEE EMC chapter (of which I am a founding member and the chapter chair) that is able to meet in the EMC Center. Our meetings have been surprisingly well attended and include anywhere from 20 - 50 people (which is quite large for a local area our size).

While the EMC Center is primarily designed to be a "teaching resource" it can fill a key need to complement commercial EMC labs (which, in general, are not pre-compliance focused). Interestingly, a local compliance lab has recognized the value of maintaining a linkage to GVSU, as it provides an opportunity for its customers to have a "baseline" of EMC when formal compliance testing is being planned. This also assists many small and medium sized companies that cannot afford pre-compliance facilities in-house, yet need to meet EMC requirements. They can utilize GVSU's resources up-front prior to testing in a formal certified EMC lab. These are highlighted in the "EMC Center brochure" that can be accessed at www.gvsu.edu/engineering/EMCCenter.

Mark Steffka: Since we are on the topic of the testing that the EMC Center can provide, can you tell us how you choose the test equipment in the EMC Center?

Dr. Adamczyk: This is a good point – we seek the guidance from our industry partners. They are involved in the day-to-day engineering work and are very familiar with what instrumentation and test equipment needs are. Since we want to assist them in their work – we listen closely to their suggestions. We have also be fortunate to receive a number of items as donations, and recently we have had the opportunity to receive full chambers as donated items – which substantially increases our educational content and assistance to industry. Another aspect that has worked well is the fact that some of our equipment is designed and built by our own students – thus enhancing their education and our resources on a very cost effective basis.

GTEM Cell at the EMC Center

Mark Steffka: Dr. Adamczyk, you have done an incredible job of creating and implementing EMC at GVSU. What final pieces of advice would you have for other universities? What do you think was key to your success? What would you have done differently?

Dr. Adamczyk: The key enabler was the support of the administration establishing and building the personal relationships with industry EMC professionals based on mutual EMC interest. Along with that, the willingness to work hard (including many nights and weekends) was absolutely critical. Without those steps – this may have been perceived as just an "academic exercise" – of minimal value to the needs of industry. What would I have done differently – about the only thing would be to have started earlier than 2005!

Mark Steffka: Dr. Adamczyk, thank you very much for the hard work you have done in EMC and the time you have taken to talk to me. In closing could you tell us what you think about the future of EMC? What advice do you have for engineering students?

Dr. Adamczyk: Each graduating electrical or computer engineering student should have some

basic knowledge of EMC. Many schools recognize that and introduce the EMC education at the undergraduate level. In answer to what is my advice – it's really quite simple. In addition to doing well in their academic studies, students should always strive to be involved in professional societies and maintain a network of colleagues. This is key to the engineering practice!

Dr. Adamczyk teaches electromagnetics and electromagnetic compatibility (EMC) courses at GVSU; he also provides EMC courses for local industry. Dr. Adamczyk is an iNARTE-certified EMC Master Design engineer, a founding member and the chair of the IEEE EMC Chapter of West Michigan. He has developed and manages the EMC Center at GVSU to support EMC pre-compliance testing and EMC education for GVSU and local industry.

Dr. Adamczyk joined GVSU in 1999 after having worked for several years in the automotive industry. He holds a BSEE and an MSEE from the University of Nevada, Reno, and a Ph.D. in Systems Engineering from Oakland University in Michigan. IN

(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. He may be reached at msteffka@umich.edu.

2013 IEEE International Symposium on Electromagnetic Compatibility

WINDS OF CHANGE

August 5 - 9, 2013 • Denver, Colorado

Technology is advancing at a MILE HIGH pace and EMC testing is necessary to the success of this progress. No longer are the boundaries of EMC testing relegated to open area test sites, laboratories and text books; they are becoming part of our daily lives. The electric and hybrid vehicles and the Smart Grid, are two big arenas where EMC plays a major role.

The EMC 2013 Symposium will include many topics to enhance your understanding of EMC, sharpen your design skills, and perfect your skills in dealing with EM phenomena. Join us in the Mile High City for a week of learning, collaboration and connecting with industry peers and start your path into the world of EMC green.

Learn the Leading Edge Info on:

- EM Interference and Environments
- Shielding, Grounding, Bonding
- EMP, Lightning, ESD
- Transient Suppression
- EMC Measurement
- Signal Integrity
- EMC Management
- Nanotechnology
- Spectrum Management
- EM Product Safety

For Event Details Visit: **www.emc2013.org**

IEEE EMC SOCIETY®

(chairman's welcome)

Dear EMC Community,

On behalf of the EMC 2013 Committee, I would like to thank you for attending the 2013 IEEE International Symposium on Electromagnetic Compatibility in Denver, Colorado. I would also like to extend a welcome to the Denver Section of the IEEE and to our local Electromagnetic Compatibility Society Chapter.

This year's Symposium Organizing Committee has worked hard to design the 2013 EMC Symposium with the goal of ensuring an enriching experience along with networking opportunities through multiple exhibits, technical programs, companion programs, and social events.

We have planned three days of top-rated, peer-reviewed technical papers presented by experts in multi-track sessions and two days of practical workshops and tutorials, experiments and demonstrations presented by industry professionals. Also included are collateral industry meetings and a full exhibit hall to learn about the latest offerings in EMC products and services.

We have some excellent educational workshops in our agenda such as "Grounding – Concepts and Physics Workshop" and "Advanced Computational Electromagnetics and Multi-Physics Methods." On Wednesday morning in the Exhibits Hall, experts in all areas of EMC and Signal Integrity will be available to answer questions in our "Ask the Experts" panel discussion. In addition, this year we are trying out a new online scheduler that will allow you to build your symposium schedule on various types of portable electronic devices.

We look forwarding to visiting with you at the Welcome Reception Katie Mullen's Irish Restaurant and Pub on Tuesday evening. It's sure to be a great night of networking and reconnecting with friends. The Self-Guided Brewery Tour is bound to be another popular social event. Denver has a well-known reputation for excellence in craft brewing and has been touted as the Beer Capital of the U.S. This is an opportunity to sample some of the local breweries with your fellow EMC Society members. It's a walking tour, of course! And for attendees who want to enjoy a bit of fresh air and exercise, you might consider joining the first annual Team EMC bike ride on Tuesday morning. It's a leisurely exploration of some of the many bike trails in Denver.

As you can see, we have a lot to offer this year. I am so glad you decided to join us for EMC 2013 in the Mile High City – Denver, Colorado.

Danny Odum

General Chairman
2013 IEEE International EMC Symposium
dan.odum@ametek.com

Danny Odum

(welcome to Denver)

Welcome to Colorado

As the Governor of Colorado, it is my great pleasure to welcome the 2013 IEEE International Symposium on Electromagnetic Compatibility - WINDS OF CHANGE to our beautiful state.

We are pleased and honored to have you here. Colorado is blessed with outstanding scenery and beauty, while our climate is the envy of the nation. Our Rocky Mountains provide unlimited recreational opportunities, and we hope you will also have time to explore some of our fascinating historical and cultural attractions.

Colorado is open to innovation and ideas. Many of our most successful businesses were started by people who first came here to attend a meeting. If you are interested in opening a business in Colorado, we would love to assist you.

I wish you the best for a successful event. Have a safe and productive stay in our state, and please come again soon.

Sincerely,

John Hickenlooper
Governor, State of Colorado

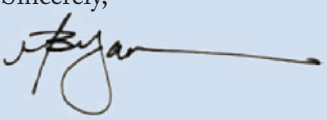
Welcome to the Mile High City!

Denver is honored to host the 2013 IEEE International Symposium on Electromagnetic Compatibility - WINDS OF CHANGE.

We invite you to explore our city and experience all that it has to offer. From seven pro sports teams to the nation's second largest performing arts complex and the mile-long 16th Street Mall to our many museums and cultural facilities, Denver is filled with attractions to entertain you.

Our many neighborhoods like Cherry Creek, Highlands, LoDo, Uptown, Five Points, Golden Triangle and Old South Pearl are filled with outstanding restaurants and one-of-a-kind shops, while after dark, Denver is a center for live music. Whether you visit one of our parks like Red Rocks Park and Amphitheatre or borrow a B-cycle and take a bike ride on our 850 miles of off-street bike paths, you'll find that Denver has 300 days of bright sunshine a year. At an elevation of 5,280 feet above sea level, Denver is truly a mile high…and climbing. Have a wonderful conference and enjoy your stay!

Sincerely,

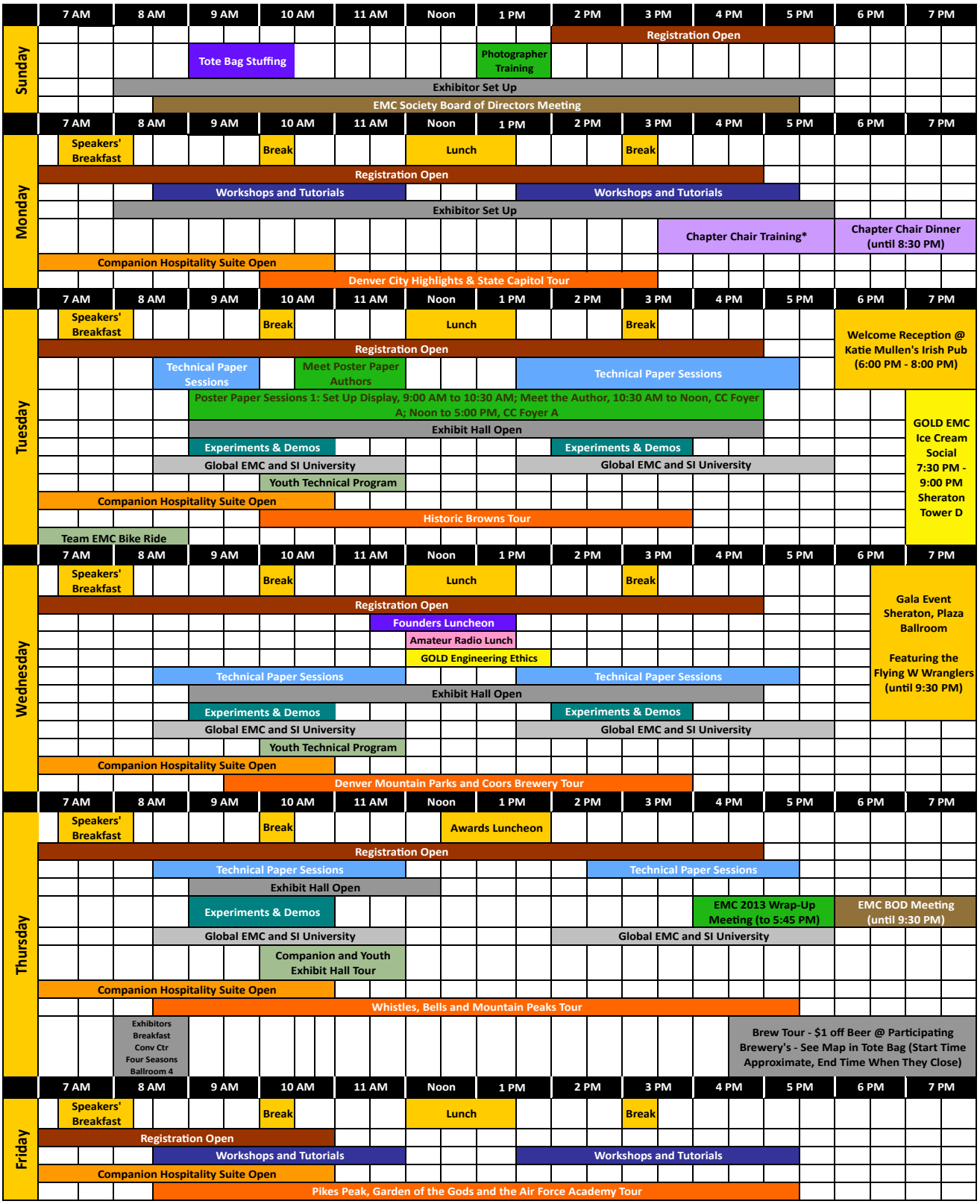


Michael B. Hancock
Mayor, City of Denver

Exhibit Hall Hours

Tuesday . . . . . 9:00 AM to 5:00 PM
Wednesday . . . . . 9:00 AM to 5:00 PM
Thursday . . . . . 9:00 AM to 12:30 PM

(Symposium-at-a-Glance)



* Monday - Chapter Chair Networking, 3:30 PM to 4:00 PM

(Technical Program Overview)

Monday, August 5

8:30 AM – Noon

- MO–AM–1 Fundamentals of EMC
- MO–AM–2 Measurement Uncertainty – Challenges and Solutions
- MO–AM–3 Introduction to EMI Modeling Techniques
- MO–AM–4 Introduction to EM Information Leakage from Electronic Devices
- MO–AM–5 Low Frequency EMC within the Smart Grid Including Interference Between Equipment for Renewables and Smart Meters

1:30 PM – 5:30 PM

- MO–PM–1 Fundamentals of EMC
- MO–PM–2 Recent Developments in EMC for Emerging Wireless Technologies
- MO–PM–3 How to Break Complex Systems into Realistic, Solvable, Accurate Models
- MO–PM–4 EMC Consultant's Toolkit
- MO–PM–5 EMC Leadership Training

Tuesday, August 6

8:30 AM – Noon

- TU–AM–1 RF Interference and Wireless Measurement
- TU–AM–2 EM Modeling and Validation
- TU–AM–3 Statistical Analysis and Model Validation
- TU–AM–4 Transportation Systems
- TU–AM–5 Special Session Spectrum Analysis and Measurements in a Congested Electromagnetic Environment
- TU–AM–6 Technical Committee Poster Session

1:30 PM – 5:30 PM

- TU–PM–1 Reverberation
- TU–PM–2 Low Frequency EMC
- TU–PM–3 Practical Applications of Numerical Modeling
- TU–PM–4 Special Session High Speed Signaling Design Optimization

Don't miss...

Grounding Workshop – Concepts, Physics and Myths

Friday, August 9

New in 2013 will be a "Grounding" workshop which will highlight various 'grounding' myths popular over the years, what is a 'ground loop' and when should we be concerned, the true purpose of 'ground', and what does the term 'ground' mean when in outer space? Speakers will include Henry Ott, Bruce Archambeault, and Bob Scully. A panel discussion will follow for audience interaction with these speakers and other well-known EMC experts.

Advanced Computational Electromagnetics and Multi-Physics Methods Workshop

Friday, August 9

There is much to be learned in our full-day workshop titled "Advanced Computational Electromagnetics/ Multi-physics Methods for Fast Characterizing Electromagnetic/Electromagnetic-Thermal Effects in Complex Structures." The objective of this workshop is to demonstrate exciting and new progress in the development of computational electromagnetics/ multi-physics methods for fast characterization of electromagnetic/electromagnetic-thermal effects in complex 3-dimensional structures, systems and platforms, which are very challenging problems for most researchers in the fields of EMC, EMI reduction and EM protection.

Wednesday, August 7

8:30 AM – Noon

- WED-AM-1 Measurements – General
- WED-AM-2 Radiation and Susceptibility
- WED-AM-3 Nanotechnology and Advanced Materials
- WED-AM-4 Managing Risk in EMC Compliance
- WED-AM-5 Special Session (TC5) New Developments in Intentional Electromagnetic Interference (IEMI)

1:30 PM – 5:30 PM

- WED-PM-1 Antennas
- WED-PM-2 Shielding, Transmission Lines and Grounding
- WED-PM-3 Time Domain Methods
- WED-PM-4 Special Session Nanotechnology in EMC
- WED-PM-5 Special Session System Level SI/PI Analysis for High Speed Design

Thursday, August 8

8:30 AM – Noon

- TH-AM-1 Measurements I
- TH-AM-2 Emissions, Filters and Enclosure Suppression Techniques
- TH-AM-3 Wireless EMC
- TH-AM-4 Special Session EMC in and on Transportation Structures
- TH-AM-5 Signal Integrity Enhancement and Crosstalk Managnement

2:30 PM – 5:30 PM

- TH-PM-1 Measurements II
- TH-PM-2 Special Session (SC4) EMC for Emerging Wireless Technologies
- TH-PM-3 Reverberation Chambers and Rectangular Cavities
- TH-PM-4 High Power EM including Intentional EMI, ESD, and Lightning
- TH-PM-5 Signal Integrity and Power Integrity

Friday, August 9

8:30 AM – Noon

- FR-AM-1 Advanced Computational Electromagnetics/Multi-physics Methods for Fast Characterizing Electromagnetic/Electromagnetic-Thermal Effects in Complex Structures
- FR-AM-2 Basic EMC Measurements
- FR-AM-3 The Scoop on Hybrid Antennas – Dispelling the Controversy for Qualification Testing
- FR-AM-4 Fundamentals of Signal and Power Integrity
- FR-AM-5 Grounding – Concepts, Physics and Myths

1:30 PM – 5:30 PM

- FR-PM-1 Advanced Computational Electromagnetics/Multi-physics Methods for Fast Characterizing Electromagnetic/Electromagnetic-Thermal Effects in Complex Structures
- FR-PM-2 Application of Reverb Chambers
- FR-PM-3 Advanced Topics in Signal and Power Integrity
- FR-PM-4 Best Practices for Organizing and Hosting Lessons Learned Discussions
- FR-PM-5 EMC in 3D Integration

Online Program Personal Scheduler

This year, conference participants may access the conference program online schedule via internet connected smartphones, tablets, laptops, or desktops. The Online Program Personal Scheduler feature allows attendees to create an account and build their symposium schedule. Search or browse presentations/sessions at the conference and check for scheduling conflicts while building your itinerary.

For instructions on how to use this tool, visit:
http://emc.confex.com/emc/2013/schedule/index.cgi

SAVE THE DATE

EMC LIGHTS THE WAY!

AUGUST 3-8 • RALEIGH • NORTH CAROLINA

EMC 2014 Symposium will be shedding light on new technology and helping you to stay abreast of current EMC testing and engineering.

New in 2014 will be an embedded conference for signal and power integrity.

Plan ahead to join us in the City of Oaks - Raleigh, North Carolina, for a week of learning, collaboration and networking with industry peers. The Symposium has something for everybody; from rookie to veteran, across all industries and academia.

NEW FOR 2014!

2014 IEEE International Conference on Signal and Power Integrity (SIPI-2014)

- Signal/power integrity for chip/package/board/connector/cable design
- Signal integrity and power integrity co-simulation
- Design, analysis, simulation, modeling and measurement techniques
- High-speed interconnect design and optimization (component and/or system level)
- PDN (power delivery network) design and optimization
- Jitter/Noise/Crosstalk and BER analysis
- System-level SI/PI/EMI co-design

IEEE

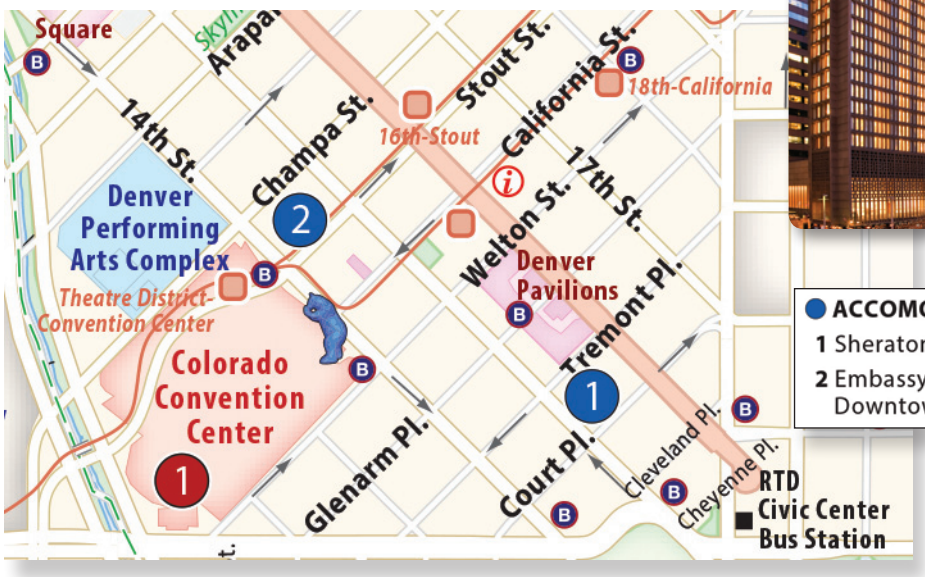
EMC SOCIETY

For Event Details Visit:
www.emc2014.org

(Accomodations and Transporation)

SHERATON DENVER DOWNTOWN HOTEL

1550 Court Place Denver, CO 80202
Phone: 303-893-3333



EMBASSY SUITES DENVER – DOWNTOWN/CONVENTION CENTER

1420 Stout Street, Denver, CO 80202
Phone: 303-592-1000

GROUND TRANSPORTATION

There are numerous ground transportation options available at Denver International Airport. The Ground Transportation Information Counter is located in the central area on Level 5 of Jeppesen Terminal. Counter hours are 6:30 a.m. to 11:30 p.m. daily.

Services include:

- Destination information for companies serving the airport
- Maps and directions to transportation pick-up/drop-off areas
- Hotel shuttle information
- Brochures and printed materials for companies serving the airport
- Arrangements for large groups

Contact Ground Transportation at (303) 342-4059 or e-mail: ground.transportation@flydenver.com.

RENTAL CAR OPTIONS

Advantage Rent A Car, (800) 777-5500

Alamo Rent A Car, (877) 222-9075

Avis Rent A Car, (800) 230-4898

Budget Rent A Car, (800) 527-0700

Dollar Rent A Car, (800) 800-3665

E-Z Rent-A-Car, (800) 277-5171

Enterprise Rent A Car, (800) 261-7331

Fox Rent A Car, (800) 225-4369

Hertz Rent A Car, (800) 654-3131

National Rent A Car, (877) 222-9058

Payless Rent A Car, (800) PAY-LESS

Thrifty Car Rental, (800) 367-2277

(Social Events)

Welcome Reception

KATIE MULLEN'S IRISH PUB

Tuesday, August 6, 2013

One ticket to this event is included in all 5-Day technical registrations and the Companion Program registration. All others may purchase a ticket to the Welcome Reception as an add-on to your registration.

An Adult Reception Ticket price: $65

A Junior (Age 8 to 17, inclusive) Reception Ticket is: $35

Children under age 8 are free, but must be accompanied by a registered adult.

Gala Event

SHERATON, PLAZA BALLROOM
Evening Entertainment, The Flying W Wranglers

Wednesday, August 7, 2013

One ticket to this event is included in all 5-Day technical registrations EXCEPT student registrations. This is a change from last year, made to keep student registration costs down. Extra tickets to the Gala may be purchased as an add-on to your registration.

An Adult Gala Ticket is: $90

A Junior (Age 8 to 17, inclusive) Gala Ticket is: $45

Children under age 8 are free, but must be accompanied by a registered adult.

Awards Luncheon

CONVENTION CENTER, FOUR SEASONS BALLROOM 1

Thursday, August 8, 2013 12:30 PM – 2:00 PM

The Awards Luncheon will be held on August 8. The Awards Luncheon will be the last formal opportunity to gather and network with families and EMC professionals from academia, industry, government, military, and retired sectors. The event will start off with a catered sit-down meal. Afterwards, the EMC Society will take time to recognize members and non-members for their contribution to the Society and for professional excellence.

One ticket to this event is included in all 5-Day technical registrations. All others may purchase a ticket to the Awards Luncheon as an add-on to their registration.

An Adult Awards Luncheon Ticket is: $50

A Junior (Age 8 to 17, inclusive) Awards Luncheon Ticket is: $25

Children under age 8 are free, but must be accompanied by a registered adult.

Anticipated Awards

- Best Symposium Paper
- Best Visual Poster Paper
- Best Student Paper
- Special Service
- Richard R. Stoddart Award for Outstanding Performance
- Lawrence G. Cumming Award for Outstanding Service
- President's Memorial Award 2nd Year Extension
- President's Memorial Award
- Technical Achievement Award
- Honorary Life Member Award
- Certificate of Appreciation
- Certificate of Acknowledgement
- Certificate of Recognition
- Hall of Fame
- Sustained Service
- Symposium Chair Award
- Richard B. Schultz Best Transactions Paper Award

(Social Events)

Chapter Chair Training Session and Dinner

TRAINING SESSION: CONVENTION CENTER ROOMS 709/711 DINNER: CONVENTION CENTER ROOMS 702/704

Monday, August 5, 2013 3:30 PM – 8:30 PM

The Chapter Chair Training Session provides a forum for providing focused training to the Chapter Chairs, provides the Chapter Chairs with the opportunity to discuss their chapter issues and get group feedback, gives the Chapter Chairs the opportunity to meet other Chapter Chairs from around the world and for the Chapter Coordinator to disseminate important information from IEEE headquarters and the EMC Society Board of Directors.

A Social Session will precede the Dinner, to give the Chapter Chairs the opportunity to socialize with the other Chapter Chairs and their Angels. The Dinner will be served at the end of the Social Session. Besides a great meal, each Chapter Chair, or their representatives, will have the opportunity to share what their chapter has been doing for the past year. After the Dinner, an interactive brainstorming session will conclude the meeting. This session is intended to exchange information and new ideas for effective chapter management, as well as to discuss best practices and suggestions for future development and growth of the EMC chapters.

This is a free event open to Chapter Chairs or their representatives.

Founder and Past-Presidents Luncheon

CONVENTION CENTER ROOMS 702/704

Wednesday, August 7, 2013 11:30 AM – 1:30 PM

The Founders and Past-Presidents Luncheon will be held at the convention center. The Luncheon is open to the Founders of the EMC Society, Past-Presidents of the EMC Society, current members of the Board of Directors, and students. The luncheon is a chance for the old and the new to mix, exchanging experiences of the past, challenges of the future and learning about the EMC profession. A sit down lunch is provided. When making your reservation, please indicate that you plan to attend so there will be seating and food for you.

GOLD EMC Ice Cream Social

THE SHERATON HOTEL, TOWER D
(After the Tuesday Welcome Reception)

Tuesday, August 6, 2013 7:30 PM – 9:00 PM

GOLD EMC will have a table to provide you with GOLD EMC information and a Raffle ticket. Only GOLD EMC eligible can receive a raffle ticket so your chance of winning is high! Look for us by the Registration desk.

Raffle Schedule:

1. At the Ice Cream Social
2. At the Engineering Ethics session
3. At the GOLD EMC Booth on Thursday during the afternoon break at 3:15 PM

Visit our Facebook page: www.facebook.com/ieeegoldemc

GOLD EMC Members or Eligible Members Only

Local Breweries: Self-Guided Walking Tour

Thursday, August 8, 2013

Denver is becoming well known for its Micro-Brewery industry. We are lucky in the fact that several small breweries are within walking distance from the convention center and hotels. Listed below are six of the breweries. Walk to these breweries at your leisure. Besides great beer, several of these breweries have great food menus. On Thursday night all of the breweries will give you $1.00 off each glass of beer if you show your EMC conference badge. Enjoy your walk and enjoy your beer responsibly.

1) Great Divide Brewing Co
2) River North Brewery
3) Breckenridge Brewer
4) Chop House and Brewery
5) Wynkoop Brewing Company
6) Rock Bottom Brewery

Team EMC

Tuesday, August 6th, 2013
Departs 7:00 AM to about 9:00 AM
Colorado Convention Center 14th Street Lobby

Interested in exploring some of Denver's many biking trails with your fellow EMCS members? The first annual Team EMC bike ride is scheduled for Tuesday morning. Please join us for a leisurely morning ride to get some exercise and to explore part of the city. August is a beautiful time of year in Denver. A Team EMC jersey will be included for participants only.

Contact Ray Adams for more details at r.k.adams@ieee.org or (310) 387-7201.

Stop by to visit our valued supporters.


SCHLEGEL electronic materials a member of EMEI Group
Agilent Technologies
HAEFELY EMC TECHNOLOGY
emtest the benchmark for emc AMETEK PROGRAMMABLE POWER
INTERMARK USA
A.H. Systems, Inc.
Pearson ELECTRONICS
533 632 531 529 628
633 732 631 730 629 728
731 830 729 828
Break Area
TRU EXPERIENCE. TRU INNOVATION.
Elite
624 622 521 519 517 616
625 724 623 722
725 824 723 822 Tech Library
825 924 823 922 821 920 819 918 817 916
921 917
Fair-Rite Products Corp. Your Signal Solution www.fair-rite.com
TIMCO ENGINEERING, Inc.
718 617 716
717
Nemko
507
812 711 709 707 806
807
913 911 909 907 905 901
ESPRESSO ENGINEERING
PANASHIELD INC.
ar
900
701
LEADER TECH a HEICO company
HV HV TECHNOLOGIES, Inc.
DMAS Dutch Microwave Absorber Solutions
ROHDE&SCHWARZ

(Exhibits)

(Exhibitor Profiles)

A.H. Systems, Inc.
Booth 616

Manufacturer
Antennas and Antenna Products

A.H. Systems manufactures a complete line of affordable, reliable, individually calibrated EMC Test Antennas and Current Probes that satisfy FCC, MIL-STD, VDE, IEC and SAE testing standards. Delivering high quality products at competitive prices with immediate shipment plus prompt technical support for the entire product line are goals we strive to achieve at A.H. Systems. We provide rental programs for our equipment and offer Recalibration Services for all our antennas and probes, including others manufactured worldwide. We take pride in providing a fast turn around schedule to help minimize any down time the customer may experience during testing. 100% inventory, NEXT-DAY ON-TIME DELIVERY.

Tel: +1 818 998 0223
Email: sales@AHSystems.com
Website: www.ahsystems.com

Advanced Test Equipment Rentals
Booth 320

Tel: +1 858 558 6500
Website: www.atecorp.com

Equipment Resellers/Rentals
Advanced Test Equipment Rentals (ATEC) supplies complete testing solutions for EMC, Electrical, Power Quality, Environmental and similar testing applications for the Defense, Aerospace, Medical and Telecom industries. Celebrating 32 years in business, ATEC takes pride in serving our customers with invaluable expertise and technical support.

Agilent Technologies
Booth 830

Manufacturer
Test and Measurement Equipment

Agilent offers EMI measurement solutions for EMC compliance and precompliance testing. The Agilent MXE EMI receiver is fully compliant with CISPR 16-1-1 2010 and includes X-Series signal analysis and graphical measurement tools that make it easy to diagnose EMI problems. To ensure successful compliance testing, MXE-identical measurements can be made—at a fraction of the price—with any X-Series signal analyzer and the EMC measurement application. Agilent Solutions Partners offer a single point of contact to purchase a complete EMC solution that meets MIL-STD and commercial specifications, combining Agilent's products with value-added integration, software, probes, antennas, chambers, and more.

Tel: +1 800 829 4444
Website: www.agilent.com/find/emc

AR RF/Microwave Instrumentation
Booth 507

Manufacturer
Antennas and Antenna Products
Test and Measurement Equipment

AR RF/Microwave Instrumentation is a manufacturer and distributor of high power broadband amplifiers from DC – 45 GHz, 1 – 50,000 watts and beyond. Our amplifiers are well suited for radiated and conducted immunity testing and equally suitable for general laboratory testing. Available are a full line of complementary test accessories including antennas, directional couplers, field monitoring equipment, power meters and EMC test software. We also offer EMI receivers, RF conducted immunity test generators and EMC/RF test systems.

Tel: +1 215 723 8181
Email: info@arworld.us
Website: www.arworld.us

ARC Technologies, Inc.
Booth 200

Manufacturer
Ferrite/Suppression Products

ARC Technologies is the leading supplier of microwave absorbing materials for commercial and defense applications. While providing a complete range of standard absorber products, ARC Technologies also offers dielectric materials, composites, radomes, and radar absorbing structures (RAS). The company's Wave-X family of products is an effective solution for EMI and SAR suppression due to their unique formulations. No matter the problem you are facing ARC Technologies has a product or will develop an application specific product to meet your specifications.

Tel: +1 978 388 2993
Email: sales@arc-tech.com
Website: www.arc-tech.com

CST of America, Inc.
Booth 409

Software Development/ Products

CST is a world leader in computer simulation of radiated emissions and susceptibly. CST MICROWAVE STUDIO(R) TLM solver (Microstripes) and CST CABLE STUDIO(TM) provide powerful features for complex EMC analysis including coupled simulations which allow for large system analysis and installed performance studies. Many years of in house expertise support the tools and give customers confidence in simulation results.

Tel: +1 508 665 4412
Email: debra.gasser@cst.com
Website: www.cst.com

(Exhibitor Profiles)

Dutch Microwave Absorber Solutions bv
Booth 709

Dutch Microwave Absorber Solutions is an independent supplier of high performance polystyrene microwave absorbers suited for all Anechoic Chambers enabling our customers to make the difference. DMAS product range consist of both hybrid (EMC) and microwave (antenna) absorbers.

The Unique Selling Point of DMAS absorbers is its absence of poisonous fire retardant chemicals. DMAS microwave and hybrid absorbers are fully compliant with REACH and ROHS.

The benefits of DMAS absorbers are:
- ✓ Unique and enhanced product design:
  - ✓ Alternate taper design (vertical – horizontal) resulting in improved reflectivity performance.
  - ✓ Light weight (5,7 kg/m2)
  - ✓ Removable tapers
- ✓ Compliant with clean room spec. class 10.000 / ISO14644-1 class 4
- ✓ Uniform carbon cell loading results in a more stable performance.
- ✓ Rigidity and superior tensile strength (no dropping tips)
- ✓ Superior product life time (>40 years)
- ✓ Resilience to humidity.

Tel: +31-71-5012526
Email: BkdeGroot@dmas.eu
Website: www.dmas.eu

Elite Electronic Engineering Inc.
Booth 718

Testing/Certification

Elite Electronic Engineering is an EMC and evironmental stress test laboratory with expertise in automotive component & whole vihicle EMC, military & commercial aviation, and FCC & C E Mark testing/ certification services.

Elite capabilities include: Approved lab for all automotive OEMs, including Chrysler, Ford, and GM. Toyota, Nissan, Honda, Mercedes, BMW, Volkswagen, CAT, CNH, Deere, International, Paccar, Volvo and Freightliner. High Powered RF Immunity Testing up to 5,000V/m. FCC, Canadian & EU Wireless Transmitter Certification Services. Combined EMC & Environmental Stress Testing

Tel: +1 630 495 9770
Email: sglaya@elitetest.com
Website: www.elitetest.com

This year there will be at least 134 exhibitors in the Symposium exhibit hall.

When you visit the show floor, please stop by to visit the fine companies who support *In Compliance Magazine*.

Tell them we sent you!

EM Test USA
Booth 521

Manufacturers
- Power Supplies
- Test & Measurement Equipment

Testing/Certification
Training & Seminars

EM TEST is the leading supplier of innovative Conducted Transient & RF immunity, Power Anomaly, and Harmonics & Flicker test and measurement solutions worldwide.
Founded in 1987, we are the gold-label supplier of choice serving customers in the Automotive, IEC, Military, Aerospace, Medical, Telecom, and Component testing industries. EM TEST is part of Ametek´s Programmable Power Division since October 2011.

Tel: +1 603 396 2680
Email: sales.emtest@ametek.com
Website: www.emtest.com

EspressoEngineering
Booth 913

Publishers
Training & Seminars

Coffee is the fuel that runs the lab and communications are by conversation. Here at Espresso we try to link the two, producing instructional and entertaining videos that you can watch in about the same amount of time that it takes to drink a cup of coffee.

Tel: +1 703 847 4700
Email: info@espressoengineering.tv
Website: espressoengineering.tv

(Exhibitor Profiles)

Enabling Your Success™
ETS-LINDGREN
An ESCO Technologies Company

ETS-Lindgren
Booth 401

Manufacturer
- Anechoic Chambers/Materials
- Antennas & Antenna Products
- Filters
- Shielding Products & Materials
- Test & Measurement Equipment

Software Development/Products
Training & Seminars

ETS-Lindgren is a leading manufacturer of turn-key systems and components for EMC, RF, wireless and acoustic testing. Our RF shielded enclosures and anechoic chambers are designed for testing a wide variety of products, from mobile handsets to full size aircraft. NEW this year is the AMS-7000 wireless reverb OTA test system; see this new test solution in booth 401!

Our popular EMCenter™ is a flexible platform that reduces system complexity and provides centralized control for making RF measurements. Proven components include antennas; turntables; field probes, monitors, and positioners; RF and EMP/HEMP/IEMI power protection filters; as well as RF and microwave absorber, including durable FlexSorb™ absorber. Innovative software offered includes TILE!™ for automated EMC test lab management and EMQuest™ for fully automated 2- and 3-D antenna pattern measurement.

Services provided include expert calibration at our A2LA accredited calibration lab and wireless testing at our CTIA Authorized Test Lab (CATL). Chamber relocation and absorber retrofit services are available upon request.

Based in Cedar Park, Texas, ETS-Lindgren has ISO 9001:2000 certified facilities in North America, Europe and Asia. For more information: www.ets-lindgren.com.

Tel: +1 512 531 6400
Email: info@ets-lindgren.com
Website: www.ets-lindgren.com

Fair-Rite Products Corp.
Your Signal Solution
www.fair-rite.com

Fair-Rite Products Corp.
Booth 716

Manufacturer
- Antennas & Antenna Products
- Ferrite/Suppression Products
- Shielding Products & Materials

Fair-Rite Products Corp. manufactures a comprehensive line of ferrite components in a wide range of materials and geometries for EMI Suppression, Power Applications, and Antenna/RFID Applications. Fair-Rite is the first U.S. soft ferrite manufacturer to receive ISO/TS 16949:2002 certification. We place the highest value on quality, engineering, and service and are dedicated to continual improvement. In addition to our standard product offering, Fair-Rite can provide custom designs and shapes to meet your specific requirements. We have an experienced team of engineers to assist you with new design and technical support. Please visit www.fair-rite.com to view our new online catalog and find contact information for customer service, applications engineers, local sales representatives, and local distributors.

Tel: +1 845 895 2055
Toll Free: +1 888 324 7748
Email: ferrites@fair-rite.com
Website: www.fair-rite.com

HAEFELY TECHNOLOGY EMC

Haefely EMC Tech
Booth 625

Manufacturer
- Test & Measurement Equipment

As a leader in the field of EMC, HAEFELY EMC Technology has a full range of conducted immunity test equipment designed to simulate the effects of interference sources on electronic, electrical and telecommunications products. Most prevalent and included in both IEC and EN product standards are the «classic» EMC tests for electrostatic discharge (ESD), electric fast transient/burst (EFT), lightning surge, magnetic fields (MF), and power line quality. Our objective is to provide the best-in-class range of instruments that are flexible enough to be used in many applications including CE Marking, product development, type verification, product safety, component and production testing.

Tel: +1 845 230 9240
Email: emcsales@hipotronics.com
Website: www.hipotronics.com

The Pikes Peak Railway, located about an hour and a half south of Denver in Colorado Springs, is the highest cog railway in the world, traveling 8.9 miles from 6,571 feet to the summit at 14,110 feet.

In 1893, while on top of nearby Pikes Peak, Katharine Lee Bates was inspired to write the words to "America the Beautiful."

(Exhibitor Profiles)

HV TECHNOLOGIES, Inc.
Booth 806

Manufacturer
Test & Measurement Equipment

The staff of HV TECHNOLOGIES, Inc. (HVT), with our partners: EMC Partners, Prana, Montena, and Teseo are focused on providing our clients with top quality, full compliant EMC test instruments. Our staff has been supporting the EMC testing community by designing, producing, and distributing the best in EMC test instruments for over two decades. We cover all aspects of EMC testing for immunity and emissions. When using our products, customers experience the most reliable test instruments with the cleanest most repeatable measurements. This has been possible through innovative product design and the deployment of unique leading-edge technologies. The highest level of support is our main focus and part of every product.

We have the products, delivery, and support you need today and for years to come.

Tel: +1 703 365 2330
Email: emcsales@hvtechnologies.com
Website: www.hvtechnologies.com

In Compliance Magazine
Booth 317

Publishers

In Compliance Magazine offers in-depth coverage of worldwide regulatory compliance issues for manufacturers of electronic products. Monthly technical features focus on designing and testing products to comply with domestic and international requirements. Major topics include EMC, Product Safety, Telecommunications, ESD, and Environmental Issues.

Tel: +1 978 486 4684
info@incompliancemag.com
www.incompliancemag.com

Intermark-USA
Booth 828

Tel: +1 408 971 2055
Email: sales@intermark-usa.com
Website: www.intermark-usa.com

Intermark USA Inc (A Kitagawa Company) is a leading provider of EMI solution products, thermal solution products, shock/vibration management products as well as plastic components. We offer a wide variety of EMC solution products such as EMI Absorbers, EMI Gaskets, EMI Tapes, EMI Ferrites, Cable Shielding Materials, and EMI Grounding Components.
The thermal solutions we offer are used in a variety of electronic applications and industries including computers, laptops, tablet PCs, smart phones, routers, LEDs, medical devices, power supplies, wireless devices, and the automotive industry. Our new product, MG-10A EMI absorber, will be shown at IEEE Denver this summer.

Local boosters named the frontier mining camp on the South Platte River "Denver" after Kansas Territorial Governor James Denver in hopes of gaining political favor. Unfortunately, Denver had retired by the time they named the town.

Leader Tech, Inc.
Booth 907

Manufacturer
Conductive Materials
Ferrite/Suppression Products
Shielding Products & Materials
Leader Tech is a world-leading innovator and U.S. manufacturer of EMI shielding products for circuit boards, electronic enclosures and interconnect cables.

Our core products:
- Standard and Custom Circuit Board Shields
- Beryllium Copper Fingerstock EMI Gaskets
- Board Level Shields / PC Board Shields
- Conductive Elastomers
- Ultrasoft Gaskets
- Advanced RF Absorber Materials
- EMI/RFI Ferrites
- 12 MIL-DTL 83528E Certified Compounds
- Standard and custom extrusions & moldings
- Silicone, Fluorosilicone and EPDM elastomers

Tel: +1 813 855 6921

Liberty Labs, Inc. - World Cal, Inc.
Booth 707

Testing/Certification

Between Liberty Labs, Inc. (A2LA Accredited) and World Cal, Inc. (A2LA Accredited) we can meet your calibration requirements from antennas and accessories to test instrumentation. We strive for prompt turnarounds and quality service. Liberty Labs, Inc. is also a U.S. Distributor of Austrian Research Centers and Schwarzbeck products. Please check out our website for more details.

Tel: +1 712 773 2199
Email: info@liberty-labs.com
Website: www.liberty-labs.com

(Exhibitor Profiles)

National Technical Systems (NTS)
Booth 211

Software Development/Products
Testing/Certification
Training and Seminars

NTS is the largest independent provider of EMC services in North America with 8 locations to provide you with world-class product compliance services. Our state-of-the-art labs offer EMC, Product Safety, Wireless and Telecommunications engineering and compliance testing. Our expert engineers and test technicians take the time and put forth the effort to understand your business, your needs and your goals and combines this knowledge with our own compliance and testing expertise to help you create successful products.

Tel: +1 800 270 2516
Email: info@nts.com
Website: www.nts.com

Nemko USA, Inc.
Booth 817

Testing/Certification

Nemko contributes to a safer world by sharing knowledge and safeguarding products, environment, people and systems. Nemko creates value for the customer by providing fast and reliable global market access. With offices in 24 countries including local labs in San Diego, Dallas, Salt Lake City and Ottawa, Canada, plus partner labs in every region of the U.S., Nemko is prepared to serve you.

Tel: +1 813 528 1261
Email: andrew.robbins@nemko.com
Website: www.nemko.com

Oak Mitsui Technologies
Booth 430

Manufacturer
- Filters
- Passive Electronic Components
- Shielding Products & Materials

Oak-Mitsui Technologies is the leading global company at developing and manufacturing advanced technology ultra thin laminates for Embedded Capacitance for current and next generation PCBs, modules, and package substrates. FaradFlex® is the market leading family of ultra thin laminate materials that has properties that minimize resonance, EMI, eliminates system noise, and improves signal and power integrity.

Tel: +1 513 313 1905
Email: robert.carter@oakmitsui.com
Website: www.oakmitsui.com

There were originally three separate towns, with three separate names, where Denver now stands. In 1859, the other names were dropped in return for a barrel of whiskey to be shared by all.

Fittingly enough, the first permanent structure in Denver was a saloon.

Panashield, Inc.
Booth 711

Manufacturer
- Anechoic Chambers/Materials
- Shielding Products & Materials
- Test & Measurement Equipment

Panashield designs, supplies, installs and certifies the following: RF Shielded Enclosures; EMC Chambers, Compact, 3meter, 5meter, 10meter; Military 461E and DO160 Avionics Test Chambers; Free Space Simulation Chambers; Reverberation Chambers; CISPR 25 Chambers for Automotive Testing; P3 RF Sliding Doors; Turnkey Services; Facility Relocations; Upgrades to existing facilities, including LED lighting solutions. Channel Partner with Diamond Engineering, a leader in Antenna Measurement Systems.

Tel: +1 203 866 5888
Email: girard@panashield.com
Website: www.panashield.com

Pearson Electronics Inc.
Booth 723

Manufacturers - Test & Measurement Equipment

Pearson Electronics manufacturers Precision Wide Band Current Probes used for accurate measurements of EMI, surge, lightning, pulse and other complex current wave shapes. New from Pearson Electronics is the Powerline Ripple Detector which greatly simplifies the measurement of injected ac ripple on an ac power bus required in MIL-STD-461 CS101.

Tel: +1 650 494 6444
Email: dalbrecht@pearsonelectronics.com
Website: www.pearsonelectronics.com

(Exhibitor Profiles)

Quell Corporation
Booth 132

Manufacturer
Ferrite/Suppression Products
Filters

EESeal® EMI Filter Insert - Instantly Add an EMI Filter to Your Connector

Quell Corporation's EESeal turns your ordinary connector into a filter connector in less than 60 seconds. The thin elastomeric insert is easily installed into the mating side of your connector, even in the field, with no special tools, no soldering, and no worries. It connects capacitors/components between selected pins and the shell. EESeal is a proven, reliable, permanent solution that has been extensively tested to ensure it is suitable for hi-rel and aerospace environments, with over 900,000 EESeals shipped to satisfied customers! Extensive technical support is provided by Quell EMI engineers. ISO9001 & AS9100 Certified.

Get a FREE CUSTOM SAMPLE shipped within 24 hours, just by asking at www.eeseal.com.

Tel: +1 505 243 1423
Email: EESeal@quell.us
Website: www.eeseal.com

Rigol Technologies USA
Booth 129

Manufacturer

Rigol Technologies is an emerging T&M leader and a technology innovator in Electronic Measurement and Chemical Analysis. RIGOL's premium line of products includes Digital Oscilloscopes,RF Spectrum Analyzers, Digital Multimeters,Function/ Arbitrary Waveform Generators, Digital Programmable Power Supplies, HPLC and UV-Vis Spectrophotometers, which help the engineers, researchers,educators to address their measurement challenges in confidence with affordability than even before.

Tel: +1 440 232 4488
Email: jason_chonko@rigol.com
Website: www.rigolna.com

Rohde & Schwarz
Booth 701

Manufacturer
Antennas and Antenna Products
Test and Measurement Equipment
Software Development/Products

Rohde & Schwarz is one of the world's largest manufacturers of electronic test & measurement, communications and broadcasting equipment. With over 40 years of EMC and EMI measurement experience, Rohde & Schwarz's broad EMC & field strength test equipment product portfolio provides accurate results across a wide 3 GHz to 67 GHZ frequency range. Rohde & Schwarz not only offers EMC, EMI, EMS and EMF test equipment for pre-compliance and full-compliance measurement, but it also provides customers with complete turnkey systems. Rohde & Schwarz test solutions significantly enhance productivity and product performance by enabling precise results to be achieved when measuring complex waveforms. For more information, visit www.rohde-schwarz.us/en/products/test_and_measurement/emc_field_strength/products.

Tel: +1 888-TEST-RSA
Email: customer.support@rsa.rohde-schwarz.com
Website: www.rohde-schwarz.com

Schlegel Electronic Materials, Inc.
Booth 529

Schlegel EMI Introducing Green Products

As the inventor of the fabric over foam technology, we are looking ahead to your EMI Shielding needs. Schlegel EMI is introducing Halogen Free V0 products and Tin copper cladding. Start designing your gaskets now and you don't have to change them later due to RoHS, REACH or WEEE requirements.

Tel: +1 585 643 2000
Email: schlegelemi.na@schlegelemi.com
Website: www.schlegelemi.com

The dome of the State Capitol in Denver is covered with 200 ounces of 24K gold. But the real priceless material is inside the building, where the wainscoting is made of Colorado onyx, a rare stone found near Beulah, Colorado. The entire world's supply was used in this building and no more has ever been found.

(Exhibitor Profiles)

Spira Manufacturing Corporation
Booth 517

The Inspiration in EMI Gaskets
Spira Manufacturing Corporation has been serving the EMC community with quality engineered EMI/RFI shielding products for over 30 years! We are AS9100/ISO-9001 certified and offer the finest most reliable EMI/RFI shielding gaskets in the market. Spira's strength lies in our exceptional products, on-time delivery, superior customer service, and technical support.

Spira's patented EMI/RFI and environmental gaskets offer excellent solutions for both cost-sensitive and high-performance applications. The unique spiral design offers extremely low compression set, long life and high shielding. Gaskets available in: groove or surface mount, EMI and Environmental protection, Honeycomb Filters, Connector-Seal Gaskets, O-Rings, Die-Cut Gaskets, and custom configurations. Our shielded honeycomb filters offer the performance of a welded panel at the price of aluminum. Flexi-Shield is soft, durable and offers a rain/wind/dust seal like elastomers. Our new Connector-Seal gaskets provide the best EMI & Environmental seal on the market! Visit our website for more info, free samples and an EMI Educational seminar.

Tel: +1 818 764 8222
Toll free: 888-98-SPIRA or 818-764-8222
Email: sales@spira-emi.com
Website: www.spira-emc.com

The round brass cap embedded in the western entrance stairs of the State Capitol marks the exact elevation of 5,280 feet (1 mile) above sea level.

TESEQ, Inc.
Booth 309

Manufacturer
Antennas and Antenna Products
Test and Measurement Equipment
Software Development/Products

Teseq, Inc. was formerly known as Schaffner Test Systems, until a management buyout was finalized in November 2006. The company provides EMC instrumentation and test Systems for radiated and conducted interference in automotive, consumer electronics, telecommunications, medical, aerospace and defense industries. It has approximately 130 employees and has been accredited to perform calibration services according to ISO 17025 at its Edison, NJ laboratory. Teseq is the only pulsed immunity manufacturer in North America with an accredited calibration lab.

Tel: +1 732 417 0501
Email: usasales@teseq.com
Website: www.teseq.com

Timco Engineering, Inc.
Booth 916

Testing/Certification

Timco Engineering, Inc. is dedicated to providing testing and certification services to our customers in accordance with our scope of accreditations. We are A2LA accredited to ISO/IEC Guide 65 and ISO/IEC 17025. Timco is an approved EMC/EMI testing facility and a TCB/FCB for FCC and IC, and a NB for the EU. Our testing services include EMC, EMI, Radiocom, P25, Safety, Environmental and Battery testing. We can test for FCC, IC, CE, Korea, Chinese-Taipei, and Australia. We are recognized by EPA as an Energy Star test lab and third-party certifier for Home Electronics.

Tel: +1 352 472 5500
Email: shoffman@timcoengr.com
Website: www.timcoengr.com

TRU Corporation
Booth 924

TRU Corporation is an industry leading supplier of highly engineered, RF cable assemblies and interconnects products. For over 60 years, TRU Corporation has provided the experience and innovation required to solve complex interconnect challenges. TRU maintains the highest level quality standards and a dedicated Application Engineering team to ensure we continually meet our customer's needs. Our high quality products are used in many demanding applications in EMC, commercial wireless, defense, aerospace, medical and industrial equipment.

Experience TRU Innovation

Tel: +1 800 COAX-TRU
sales@trucorporation.com
www.trucorporation.com

TÜV Rheinland of N.A.
Booth 301

TÜV Rheinland is uniquely qualified to help its clients get their products to market quickly. Customers can choose conveniently located EMC labs equipped with 5 and 10 meter chambers to handle a variety of products. As an EMC Notified Body (CAB) and international service provider, we offer a flexible, competent service to help you meet the requirements of the EMC directive 2004/108/EC as well as FCC and Industry Canada requirements. For wireless radio compliance needs, TÜV Rheinland is a TCB for the U.S. and an FCB for Canada and can provide the wireless product certifications required.

***All TÜV Rheinland's EMC labs are 17025:2005 accredited, FCC listed, VCCI registered, IC recognized and our Pleasanton, California lab carries both WiFi & Zigbee accreditations.

Tel: +1 203 426 0888 ext 119
Fax: +1 203 426 4009
Email:info@us.tuv.com
Website:www.us.tuv.com

(Show Stoppers)

We bring you an opportunity to learn about what's new and what you have to look forward to when you stop by our advertisers' booths for a visit in Pittsburgh this year.

Advanced Test Equipment Rentals (ATEC)

find us at **Booth 320**

Take advantage of the vast rental inventory of EMC test equipment that Advanced Test Equipment Rentals (ATEC) is known for! We specialize in the application of transient immunity for surge, EFT/burst, ring wave, dips and interrupts, harmonics and flicker, and ESD. ATEC supplies complete testing solutions for EMC applications in military/defense, telecom, commercial CE, aerospace and automotive markets. No other rental company has the breadth and depth of our inventory and the expertise to match your test needs with the right equipment.

- IEC 61000
- Mil-STD-461
- DO160 Sect 22
- Automotive ISO 7637
- Telcordia GR-1089
- Medical IEC60601-1-2
- DO160 HIRF
- Indirect Lightning Strike
- Harmonics & Flicker
- and many more…

You can depend on ATEC's knowledge and expertise for your EMC test equipment needs, as do the many accredited EMC test labs in North America.

Come visit us at EMC 2013, booth #320. While you are here, enter our show raffle for a chance to win a fabulous prize and then take a few minutes to place a rental order for the test equipment you need at your facility.

Order now! (888) 544-2832 or www.Atecorp.com

AE Techron, Inc.

find us at **Booth 516**

AE Techron builds the right tools for audio bandwidth EMC testing. Stop by Booth #516 to learn why.

Check out our new 4301 Series test system for Telecom testing. It is the best system available to create wave forms required by GR-1089 Section 10 and ATIS-0600315.2007 testing. The 4301 meets the 2µS rise time requirements at currents of up to 800 amps.

We also have a great solution for DO-160 Section 19 testing. Our new T2700V is the only transformer available that is designed for testing at levels up to 8100VM. Built for safety and durability, it features redundant current limits, voltage isolation, built-in DC blocking, and external high-voltage connectors with a safety rating up to 10,000V.

The AE Techron model 7224 amplifier, already the most popular audio bandwidth test amplifier in the industry, gets even better! Introducing the extended performance 7224E.

Stop by to see about the "right tools" for your EMC testing needs.

Agilent Technologies

find us at **Booth 830**

In EMC testing, success depends on the tools that can help you do more in less time—today and tomorrow. Learn how Agilent can help you keep the test queue flowing with its N9038A MXE, a standards-compliant EMI receiver and diagnostic signal analyzer built on an upgradeable platform.

The MXE EMI receiver meets both commercial (CISPR 16-1-1) and military requirements (MIL-STD-461), allowing you to fully test a range of devices with outstanding accuracy and excellent sensitivity. Easily upgrade the MXE's CPU, memory, disk drives and I/O ports to keep your test assets current and extend instrument longevity. Together with Agilent's proven customer service and a standard 3-year warranty, the MXE delivers the precision, repeatability and reliability you need to test with confidence.

In addition to full compliance measurements with the MXE, Agilent offers precompliance measurements and diagnostic evaluation with the N6141A EMI measurement application on X-Series signal analyzers. Through Agilent Solutions Partners, use a single point of contact to combine the MXE with chambers, antennas, software, value-added integration, probes and more for a complete EMI test solution.

Visit Booth 830 to find out how Agilent's EMI test solutions can support you in the lab and on the bench.

AR RF/Microwave Instrumentation

find us at **Booth 507**

What has AR done for you lately? Stop by Booth # 507 and see!

We will be demonstrating our latest state of the art products for numerous EMC applications. Our MultiStar line of products including our DSP EMI Receiver, Multitone Tester, and Field Analyzers will be on display. These products feature amazing speed and incredible accuracy and save you time and money. We have also introduced our line of .7 to 6 GHz single band

(Show Stoppers)

Class A linear amplifiers with output powers now exceeding 200 watts. Another major product release is our new W Series Class A amplifiers that are extremely efficient and deliver the power you require even into harsh loads. In additional we have developed additional new dual band solid-state Class A amplifiers that cover the .7 -18 GHz frequency band in one package.

A new family of solid-state microwave amplifiers provides power up to 1000 watts covering 1 – 2.5 GHz; making them excellent replacements for traveling-wave tube amplifiers. We're also giving you more power in our single band 0.8 – 4.2 GHz solid-state microwave amplifiers – up to 1200 watts!

Don't forget to test your AR knowledge and be entered into our daily prize drawings. There are 3 chances to win each day!

CST of America, Inc.

find us at **Booth 409**

CST will be presenting the latest developments of CST STUDIO SUITE® at booth #409

EMC and EMI issues can arise from structures and components at every scale, from aircraft and vehicle bodies down to cables and even individual seams. To simulate scenarios such as emissions or lightning strikes accurately, it can be necessary to include all these structures in the 3D simulation. However, the difference in scale between, for example, the length of a cable harness and the width of an individual conductor, or the size of an enclosure and the thickness of its seams, can make these models challenging to solve.
The TLM solver in CST MICROWAVE STUDIO® lets complex structures be represented with accurate compact models, and enables bi-directional transient co-simulation with CST CABLE STUDIO® (CST CS). The electromagnetic behavior of complex cables and cable harnesses can be modeled in a 3D environment using computationally-efficient models in CST CS, with the ability to model real shields and twisting of wires among other factors. With bi-directional simulation, it's possible to calculate the complex couplings that arise when fields absorbed by a cable in one part of the device are conducted and re-radiated in another part.

Visit booth #409 and learn more about the latest techniques for cable co-simulation and modeling across a range of scales.

Dexmet Corporation

find us at **Booth 209**

Dexmet Corporation is the leading manufacturer of precision-expanded MicroGrid® metal foils and PolyGrid® polymers for EMI, RFI and ESD shielding. They are available in most metals and alloys, or the company will work with customers' proprietary materials. Metals Dexmet regularly produces include: aluminum; brass; copper; monel; nickel; steel; stainless steel; titanium and zinc. PolyGrid provides a similar range of patterns and flexibility in a range of polymers, including Teflon and PFOA-Free expanded fluoropolymers.These ultra-thin, foil-gauge and thin-film materials offer infinitely variable geometry in three dimensions: Overall thickness or depth of pocket, open area and weight can all be precisely controlled for specific shielding characteristics. These metal foil and plastic film products are available from .001" thin, at up to 60" web width, with from 1 to 9,000 openings per square inch. Standard, diamond pattern sizes are available from .020" to 0.506". Materials can be anodized, plated, painted or plastic coated, bent, formed, and punched. The variable open area facilitates lamination with a variety of other materials, including those which expand, contract and flex. Dexmet will even design a precision expanded product with unique characteristics for your particular application.

Dutch Microwave Absorber Solutions (DMAS)

find us at **Booth 709**

After the successful introduction of the first hybrid polystyrene absorber in the summer of 2012, DMAS recently extended the hybrid absorber range with two new models. In addition DMAS also introduces three new high performance, polystyrene microwave absorbers (frequency range 70MHz - 110GHz) for antenna measurement applications. Come visit us at booth 709 to learn everything about our complete range of absorbers.

Dutch Microwave Absorber Solutions is an independent supplier of high performance polystyrene microwave absorbers suited for all anechoic chambers, enabling our customers to make the difference. The DMAS product range consists of both hybrid (EMC) and microwave (antenna) absorbers.

The unique selling point of these absorbers is the absence of poisonous fire retardant chemicals. DMAS microwave and hybrid absorbers are fully compliant with REACH and ROHS.

The benefits of DMAS absorbers are:

- Unique and enhanced product design:
  - Alternate taper design (vertical – horizontal)
  - Light weight
  - Removable tapers
- Compliant with clean room spec. class 10.000/ISO14644-1 class 4
- Rigidity and superior tensile strength (no dropping tips)
- Superior product life time (>40 years)
- Resilience to humidity.

Panashield is the exclusive channel partner for DMAS in the USA, Canada and Mexico. DMAS is part of Comtest Engineering bv.

(Show Stoppers)

EM Software & Solutions (USA), Inc. - FEKO

find us at **Booth 900**

FEKO is a comprehensive electromagnetic simulation software tool, based on state of the art computational electromagnetics (CEM) techniques enabling users to solve a wide range of electromagnetic problems. The multiple solution techniques available within FEKO make it applicable to a wide range of problems for a large array of industries.

Typical applications include EMC (analysis of diverse problems including shielding effectiveness of an enclosure, cable coupling analysis in complex environments, e.g. wiring in a car, radiation hazard analysis), Antennas (analysis of horns, microstrip patches, wire, reflector, conformal & broadband antennas and arrays), Antenna placement (analysis of radiation patterns, hazard zones, etc. with antennas placed on large structures, e.g. ships, aircrafts armored car) Bio-electromagnetics (analysis of homogeneous or non-homogeneous bodies, SAR extraction), RF components (analysis of waveguide structures, e.g. filter, slotted antennas, directional couplers (3D EM circuits: analysis of microstrip filters, couplers, inductors Radomes (analysis of multiple dielectric layers in a large structure Scattering problems (RCS analyses).

Please visit the FEKO (www.feko.info booth # 900 at the EMC symposium for more information, interesting demonstrations, brochures & articles.

EM Test USA

find us at **Booth 521**

Come to booth 521 to see the latest in Conducted Immunity test solutions for Automotive, Hybrid & Electric Vehicle, Green Energy Test Solutions, including new Harmonics & Flicker Test Solutions for Energy Regeneration systems which both consume and deliver energy back to the grid. We have our latest products including IEC & ANSI conducted immunity (Surge, Burst, Dips & Interrupts, ESD, Conducted RF and Harmonics/Flicker), MIL & Avionics Power Anomaly Test solutions, and Automotive test solutions. Technical experts are on hand to demonstrate the equipment and to answer all your questions about conducted EMC testing and the latest changes to the standards.

Stop by to meet Dan Odum, our new North American Sales Manager and chairman of this IEEE EMC symposium. Dan has nearly 30 years of experience in EMC, and we are extremely pleased that he has chosen to join the world's #1 company in conducted EMC and lead our continued expansion in the North American market.

At EM Test we celebrated our 25th birthday last year, and in our 26 years we have put together the broadest and highest-performance conducted EMC hardware portfolio, test software and standards libraries which are unparalleled in their completeness, ease-of-use and flexibility and excellent worldwide support and service led by the most experienced technical team in the industry - come by and see why we are the benchmark for EMC.

EspressoEngineering

find us at **Booth 913**

Espresso Engineering Does Denver!

Be sure to stop by our exhibit at the IEEE Show for celebrity interviews, the latest show news, product and service announcements and fun! We'll be broadcasting live from Denver and Washington all week long as we loop in the DC Expresso team to provide color commentary and some of their own surprises. Espresso favorites and the king himself, Willie Washington-everybody's favorite robot--will be making guest appearances. If your company is interested in a customized video please stop by our exhibit 913 for more information or call us at 240-401-1388. Your video will be loaded live that same day and streaming that night on the Espresso Engineering website with downloads to your company site! Make things happen in Denver with your own Espresso Video!

ETS-Lindgren

find us at **Booth 401**

Visit Booth 401 see what's new in EMC test from ETS-Lindgren!

- EMGen, a signal generator on a card, is now one of seven plug-in modules available for EMCenter™, our modular RF test platform.
- The new 7.0 release of TILE! EMC lab management software adds additional functionality to an already robust package.
- TUG, the TILE! Users Group will have its annual meeting on Wednesday morning. Stop by our booth for more info.
- Our new small-footprint antenna tower (with boresight option) takes less chamber space, and doesn't sacrifice performance.
- A new EUT table made with low dielectric materials is now available. The table's low dielectric values contribute to lower uncertainty values.
- Matching a newly developed series of pre-amps to our most popular antennas and calibrating as a unit, offers improved uncertainty values over single components.
- A newly formulated anechoic absorber with closed cell construction mated to a ferrite tile base offers broadband performance and dimensional stability.
- A reverberation chamber for wireless over-the-air (OTA) testing will demonstrated throughout the symposium – see this unique application in our booth.

(Show Stoppers)

Fair-Rite Products Corp.

find us at **Booth 716**

Fair-Rite Products Corp is Powered UP!

Our expanded Power/Inductive Materials and Components line for transformer, inverter and inductor applications is stocked and ready for delivery! We now offer THREE new materials, 95, 97 & 98 in industry standard shapes and sizes. Our expanded line provides low losses and optimum use of given volume of ferrite material for power/inductive designs up to 750Khz. The added shapes permit simplified construction of common mode EMI filters without toroidal winding complexity.

Additionally, Fair-Rite has also created a High Frequency Toroid Kit for inductive applications operating at a frequency of 1MHz and above. The kit contains eight sizes in four materials from a 6mm OD to 61mm OD. The materials are selected for optimized performance over a specified frequency range for power conversion and low loss applications. These toroids and materials can be utilized for broadband transformers and high frequency chokes as well. The toroid shape offers an ideal geometry for potential users to evaluate material relative to their electrical requirements.

In addition to our standard product offering, Fair-Rite can provide custom designs and shapes to meet your specific requirements. We have an experienced team of engineers to assist you with new design and technical support.

HV Technologies, Inc.

find us at **Booth 806**

Stop by we have the answers!
What do the new standards mean to your testing?

New standards for EFT and Surge put new verification requirements on your test equipment. Make sure you have what you need to be ready. Come talk with us we have the answers you need about upcoming conducted immunity requirements.

- IEC 61000-4-4 and IEC 61000-4-5 Edition 3 have been released or soon will be.
- MIL-STD-461G is in committee with many additions on the horizon. Be prepared.
- New requirements for Smart Grid.

CE Mark Applications

- SEE the NEW IMU3000!!! the most versatile generator on the market ○ See why it can't be matched
- High current CDNs AC and DC for any application
- ESD3000 See the best ESD simulator on the market and find out why it is preferred

Avionics Lightning and Voltage spikes

- Meet ALL levels and requirements, we can do it all!
- Airbus, Boeing, and DO160
- Future MIL-STD-461G
- New larger couplers

Solid State Amplifiers

- Class A, 100% Mismatch tolerance
- Deliver power into any load
- The power you need where you need it in the band
- Unmatched quality and great value in one package

Antennas and Accessories

- Full line of antennas, LISN, CDNs, Mag coils, … to offer

Whatever your application is, stop by our booth to discuss how our quality solutions can work best for you. We have the largest range of transient products offered by one supplier.

Nemko USA, Inc.

find us at **Booth 817**

Companies around the world trust Nemko to assess their products, systems, installations and personnel for conformity with relevant standards and regulations.

Since 1933, we have ensured that our customers comply with requirements anywhere in the world. Our services include pre-compliance, international approvals, product and system certifications as well as product testing.

Through our offices, laboratories and extensive partner network in Asia, North America, Europe, Middle East and Africa we are able to serve our customers in a reliable, efficient and open manner. We provide local presence coupled with global knowledge.

International recognition
Nemko is a founding member of several multi-national certification agreements, including the European ENEC, the international IECEE/CB-scheme and the IECEx scheme, and is a leading supplier of international certificates for electrical/electronic equipment.

Bi-lateral agreements have been signed with a number of certification bodies in Eastern Europe, Middle East, Far East, South America and Africa, in order to offer manufacturers easy global market access for their products, both for electrical equipment and telecom products.

Nemko is appointed as an official Notified Body for products falling under the European Directives for:

- Low Voltage equipment
- Medical devices
- Explosion protected equipment
- EMC (Electromagnetic Compatibility)
- Telecom equipment
- Machinery
- Marine equipment
- Automotive equipment
- Construction Products
- Noise
- Authorized for German GS-mark certification
- Authorized for Canadian national certification
- Authorised for NRTL certification in USA.

Please proceed to www.nemko.com for more information and a quotation.

(Show Stoppers)

Oak Mitsui Technologies

find us at **Booth 430**

Oak-Mitsui Technologies is the global leader at developing and providing ultra thin advanced laminates for high technology PCBs and electronics. FaradFlex® is Oak-Mitsui Technologies' leading edge family of ultra-thin laminate products used in next generation PCBs, modules, and packages. This market leading brand of materials has properties that:

- Reduce EMI
- Reduce power buss noise
- Enable embedded capacitance
- Eliminate surface mount passives
- Minimize jitter
- Improve SI
- Lower inductance
- Reduce the design form factor and weight

We look forward to seeing you at our booth and helping you with your design/material solutions.

Panashield, Inc.

find us at **Booth 711**

Panashield continues to bring new solutions to the EMC marketplace, with this year in Denver being no exception.

We will be exhibiting the Diamond Engineering DRG Horn, which Panashield will be distributing. This Horn breaks the mold for what has been the industry solution for more than 25 years.

- Broadband - 700 MHz to 26 GHz
- Increased Monotonic Gain – Superior to all existing Broadband DRGHs
- Improved Beam performance – No flowering at higher frequencies
- Custom Configurations available – Using Diamond's Single Antenna Mirror method, custom designs can be quickly configured

Panashield will also be displaying their improved LED panel lighting system and new anechoic absorbers meeting the latest international standards.

Stop by and say hello to your friends on the Panashield Team – the Team that brings the highest level of quality products and customer service to the EMC industry.

Pearson Electronics, Inc.

find us at **Booth 723**

Pearson Electronics is pleased to introduce the new Powerline Ripple Detector, Model PRD-120, which greatly simplifies the measurement of injected audio ripple on an ac power bus in measurements such as MIL-STD-461 CS101. We will be demonstrating the PRD-120's ability to make CS101 much easier, accurately measuring low-level audio ripple voltage on a 115 Vac 60 Hz power bus. In conjunction with a spectrum analyzer, the PRD-120 separates the injected ripple from the power waveform in the frequency domain allowing for accurate measurements of the injected waveform. The PRD-120 is a simplified, cost efficient way to monitor the entire frequency range in MIL-STD-461 CS101, RTCA/DO-160 section 18 and MIL-HDBK-704-2 through -6.

We will also have our Precision Wide Band Current Probes on display that are used for accurate measurements of EMI, surge, lightning, pulse and other complex current wave shapes. We will be demonstrating the performance of several probes to assist with various measurements required by the MIL-STD-461 specification. The Pearson model 3525 will be compared to other passive EMI probes to demonstrate its efficiency and its 6 decade flat transfer impedance, 10 Hz to 10 MHz, best in the industry. This probe is a great choice to meet the 30 Hz to 10 kHz frequency requirement for CE101. Stop by booth 723 to see these great demos and to also learn about our free current probe give away.

Quell Corporation

find us at **Booth 132**

Quell Corporation's EESeal turns your ordinary connector into a filter connector in less than 60 seconds. The thin elastomeric insert is easily installed into the mating side of your connector, even in the field, with no special tools, no soldering, and no worries. It connects capacitors/components between selected pins and the shell. EESeal is a proven, reliable, permanent solution that has been extensively tested to ensure it is suitable for hi-rel and aerospace environments, with over 900,000 EESeals shipped to satisfied customers! Extensive technical support is provided by Quell EMI engineers. ISO9001 & AS9100 Certified. Stop by the booth for FREE EESeal samples and a demonstration.

Rigol Technologies

find us at **Booth 129**

Get Precompliance EMC Measurements Up to 3 GHz with Rigol's Spectrum Analyzers

Rigol Technologies offers a range of spectrum analyzers designed to fit several EMC measurement needs. Rigol's DSA1000 Series Spectrum Analyzers are available with frequency ranges up to 2 and 3 GHz and have recently added free support for the Quasi-Peak detector and EMI precompliance measurements on for both new and existing DSA1000 models.

In today's design process, compliance testing has become a critical task, yet each compliance lab trip can potentially cost thousands of dollars. Rigol's latest spectrum analyzer, the DSA800 series, redefines the product category by setting new standards for performance

(Show Stoppers)

and price. With measurements up to 1.5 GHz, the DSA815 can help you verify and debug boards and products before sending to a lab, saving significant time and money… and it pays for itself by saving a single trip to the compliance lab.

Using our digital IF filter, DSA800 series have the ability to measure smaller signals, allowing for smaller bandwidth settings as well as reduced display average noise levels. Available for the low starting price of $1,295, Rigol's DSA815 gives customers a way to rethink their lab setup by offering a high performance, reliable spectrum analyzer for the cost of a digital oscilloscope. DSA815 spectrum analyzers include a preamplifier and an option for an EMI filter with a quasi-peak detector kit and 1.5 GHz tracking generator.

Rohde & Schwarz

find us at **Booth 701**

Rohde & Schwarz is one of the world's largest manufacturers of electronic test & measurement, communications and broadcasting equipment. EMC and EMI test equipment and systems from Rohde & Schwarz determine the causes and effects of electromagnetic interference.

With over 40 years of EMC and EMI measurement experience, Rohde & Schwarz's broad EMC & field strength test equipment product portfolio provides accurate results across a wide 3 GHz to 67 GHZ frequency range.

Rohde & Schwarz not only offers EMC, EMI, EMS and EMF test equipment for pre-compliance and full-compliance measurement, but it also provides customers with complete turnkey systems. Rohde & Schwarz test solutions significantly enhance productivity and product performance by enabling precise results to be achieved when measuring complex waveforms.

For more information, visit http://www.rohde-schwarz.us/en/products/test_and_measurement/emc_field_strength/products/

Spira Manufacturing Corporation

find us at **Booth 517**

Newest In**Spira**tion in EMI shielding!

- Come by booth #517 for an EMI Educational DVD by one of the leaders in EMI Shielding (FREE while supplies last!) "EMI Shielding Gasket Selection, Testing & Effective Use." It covers the requirements to select the proper EMI gasket to last the LIFE of a system and explains the importance of choosing a compatible gasket and joint surface to avoid corrosion. It also details and evaluates the accuracy of Shielding Effectiveness Test Methods and introduces a more effective Transfer Impedance Test Method.
- See our newest product inSpiration including Spira's EMI & Environmental Connector-Seal Gaskets - the unique Spira design provides the BEST environmental seal and EMI shielding for flange mounted connectors.
- Also see our Honeycomb Fan Filters and ask us about our patented blending process that makes them top quality and cost effective too.
- Talk to the EMI technical experts on your specific shielding applications.
- And don't forget your FREE boomerang – Spira has something for everyone!!

All products manufactured in California. ISO9001:AS9100 Certified. www.spira-emi.com/whatsnew

Teseq, Inc.

find us at **Booth 3069**

Serving the global electronics community, Teseq delivers test equipment, test systems and end-to-end solutions, especially for fast-evolving technology sectors that demand rapid, reliable results in compliance with current standards. Teseq's test systems are guaranteed to be standards compliant. Its systems accelerate product development and production as well as deliver immediate and reliable results.

Teseq's systems and solutions provide compatibility, connectivity, ease of use and sustainable hardware and software. With a broad product suite, Teseq employs advanced technologies and offers modular test system architectures that enable the construction of comprehensive, integrated and expandable test systems with significant ROI.

The company's user-friendly application software enables the use of convenience features that enhance efficiency and provide low-cost and customized solutions. The company also offers a worldwide network of experts to provide customers with rapid responses and effective communication. Teseq now operates internationally recognized accredited calibration laboratories for calibration services around the globe.

As of 2012, Teseq acquired UK-based MILMEGA, Ltd., a leading specialist in the design and manufacture of solid state, high-power microwave and RF amplifiers. Additionally, Teseq also acquired New York-based Instruments for Industry (IFI), a leading designer and manufacturer of solid state and traveling wave tube (TWT) amplifiers. The acquisitions expand Teseq's model range and power levels as well as strengthening Teseq's capabilities in commercial, industrial, automotive, military and communications applications.

(Show Stoppers)

Timco Engineering, Inc.

find us at **Booth 916**

Timco Engineering is an international regulatory service provider that accurately and effectively provides a timely and trusted service to our clients world wide. We keep your project plans on track and provide you with a competitive advantage in cost saving and turn around time. We understand the complexities your company may face in reaching world markets. Our technical experts know how to deal with the international regulatory issues while at the same time keeping our clients up to date with the changes that periodically arise during the investigation of your product.

Our goal is to help make your business as efficient and profitable as possible. We will work with you to help solve your problems, while understanding that you have limited resources and budget. We provide the following services: Product Safety, R&TTE, EMC & LV Directives for your Manufacturers Declaration of Conformity to support the CE mark. Energy Star, Environmental, Reliability, ESD, Susceptibility, Battery, FCC, EMC, EU, Industry Canada, Part 68, P-25, CCC China, Australia RCM, Korea, We are a TCB, FCB for the FCC and Industry Canada, EPA Recognized Certification Body and Notified Body for the EMC, R&TTE and LV Directives.

TRU Corporation

find us at **Booth 924**

TRU Corporation offers the most complete one-stop source for all your EMC RF cable assembly and connector requirements. TRU has developed a full line of RF solutions designed specifically for the EMC marketplace. Meet our knowledgeable staff at booth #924 to discuss your most challenging RF immunity and emission requirements.

See our latest products at the show:

- The TRUflex™ PWR cable assembly series provides maximum power handling for immunity testing using our highly flexible TRU-560 cable.
- The TRUcore™ series are low loss, highly durable cable assemblies that provides broadband frequency performance up to 50 GHz for emission applications.
- The highly efficient and durable TRU-QRM™ and TRU-SQS® connector interfaces eliminate threaded connections, tooling and cross-threading. A positive locking interface that allows “plug & play” mating.
- The full line of INHD™, interchangeable head, cable assemblies offer maximum flexibility to mix and match the connector interface needed for your specific testing requirement.
- A full line of access panel bulkhead adapters including TRU-QRM™ and TRU-SQS® interfaces.

TUV Rheinland of N.A.

find us at **Booth 301**

Visit us at booth #301 and meet our EMC experts. As an EMC Notified Body (CAB) and international service provider, TÜV Rheinland offers a unique service to help fulfill the EMC directive 2004/108/EC as well as FCC and Industry Canada requirements. Our number one priority is to help our clients get their products to market quickly. All TÜV Rheinland’s EMC labs are 17025:2005 accredited, FCC listed, VCCI registered, IC recognized and our Pleasanton CA lab carries both WiFi & Zigbee accreditations. TÜV Rheinland has 5 of these state-of-the-art facilities in North America alone. These labs are equipped with 5 and 10 meter chambers to handle a variety of products. We can perform tests to almost all Product Family Standards and EU Directives. For wireless radio compliance needs, TÜV Rheinland is a TCB for the US and an FCB for Canada and can provide the wireless product certifications required. For large machinery, TÜV Rheinland can perform EMC tests right at your facility. For over 140 years, TÜV Rheinland has had the experience, resources, and talented professionals you need, as a one-stop testing partner, for all your EMC, Wireless, Energy Efficiency, Market Access or Product Safety needs.

In Compliance Magazine

find us at **Booth 317**

Stop by to see us at Booth 217 this year - we’re not only giving away free subscriptions, but for our subscribers we have a free gift!

In Compliance is the leading monthly magazine in the EMC industry -- keeping you informed with news and technical articles through our print version as well as digital and bi-monthly newsletters.

Be sure to stop by to see why we’re EMC fit to a T!

EMC... fit to a T

Visit Booth #317

Sign up or renew your free subscription

Get an In Compliance t-shirt!*

**while supplies last*

IN COMPLIANCE Magazine

Reaching for the Stars

from the Lens of a Telescope

BY EDDIE PAVLU

Today's digital camera sensors have the benefit of acting like a bucket that collects photons (light) - the longer the exposure, the more light (color and detail) is captured and displayed in the photograph. Long exposures from these cameras can capture light far too faint for our unaided eyes to see. These long exposures require precise tracking of the sky. Stars are like pinpoints of light. Tracking errors quickly elongate stars in a photograph, and then they look oblong or like streaks. The equipment that is available today allows amateur astronomers the opportunity to take astrophotography images that rival the detail taken by professionals just a decade ago.

HOW IT ALL BEGAN

My interest in astronomy started when I was a young boy watching the Apollo program, hoping some day to become an astronaut. At around age 12, my parents bought me a small telescope for Christmas. I'd spend hours looking at the Moon and stars in the night time sky. Over the years my interest in astronomy took a back seat to work and other hobbies (skydiving, SCUBA, motorcycle riding ...). All that changed when my wife, Lisa, and I built our second home in a small California community called Groveland in 2003. Groveland is located about 24 miles from the north gate to Yosemite National Park. Due to the decreased light pollution compared to the San Jose Bay Area, the night time sky was alive with stars. Shortly after our house warming party, my good friend, Tom Parker, presented me with a rather large box and attached note. The note read, "You need this". Inside the box was a Celestron C5 telescope. This was not your average "department store" telescope, but rather an entry level telescope for serious amateurs. You see, Tom is an astrophotographer. He attaches cameras to telescopes and takes long-exposure photographs of deep-sky objects like galaxies and nebula. Armed with my new Celestron C5, Tom's guidance, and help from the many Yahoo groups on the internet – I too was off to become an astrophotographer.

Unknown to me, my entrance into astrophotography coincided with the digital camera revolution. This made all the difference, since film is not intended for the long exposures that are required for deep-sky objects. Over the next couple years, I self-taught myself this new hobby and slowly upgraded my astronomy equipment arsenal to accommodate the demands of deep-sky astrophotography.

MY VERY FIRST ASTROPHOTOGRAPHS

The very first photograph that I took with a telescope pointed at the night time sky was quite easy. I simply held a small digital "point and shoot" camera up to the eyepiece and took a photograph. This is a technique that

can be used with any bright object in the sky. By "bright object", I mean celestial objects that you can see with your eyes when you look up at the night time sky. This is in contrast to many of the "deep sky" photographs that I would later learn to take with very long exposures. Deep-sky objects include any celestial object that is too faint to see when you look through a telescope – like nebula and galaxies.

One of the most obvious bright objects in the night time sky is the Moon, which was the subject of my very first photograph. The "hold the camera up to the telescope eyepiece and take a photograph" technique doesn't require any expensive telescope or camera equipment. All you do is look through the telescope to find something interesting in the night time sky, and then hold your camera up to the eyepiece and take a picture. However, you should take your camera out of its "automatic" mode to get the best photographs. Use a shutter speed that is faster or an aperture that is smaller than the camera recommends when you take a photograph of the Moon (under-exposed), otherwise the picture will just look like a bright white (over-exposed) object.

I usually take many photographs with different exposure times and then keep just the ones that I like best. Printed with this article is the first photograph that I took with a telescope (Photo 1). This photograph of the Moon appears almost exactly as it appeared to my eye when I viewed it through the telescope, and reveals the many details of the cratered lunar surface.

Several years after I took this first photograph of the Moon, I was able to perfect a technique called "prime-focus" imaging, where the camera is connected to the telescope and uses the telescope as the lens. Using this technique, I revisited the Moon to take several images of a lunar eclipse.

A lunar eclipse occurs when the Moon passes through some portion of the Earth's shadow. As you might expect, this can occur only when the Sun, Earth, and Moon, are aligned exactly, or very closely so, with the Earth in the middle. The Moon does not completely disappear, even during a total lunar eclipse, because of the refraction of sunlight by the Earth's atmosphere. The Moon can appear various shades of yellow, orange, and red, because any sunlight that does reach the Moon must pass through a long and dense layer of the Earth's atmosphere, where the light is scattered. Shorter wavelengths are more likely to be scattered by the small particles, so by the time the light has passed through the atmosphere, the longer wavelengths dominate. This resulting light we perceive as red. This is the same effect that causes sunsets and sunrises to turn the sky a reddish color. The amount of refracted light depends on the amount of dust or clouds in the atmosphere.

This photograph (Photo 2) is a series of 14 separate images of the Moon taken during a 4-hour period, depicting various times/phases of the eclipse. The exposure times vary between 1/250 and 2 seconds. The time-line begins at the top of the photograph (12 o'clock position), with a full Moon, and moves clockwise. As you circle clockwise around this photograph you can see Earth's shadow begin to cover the view of the Moon. At first glance, this may appear to be the normal phases of the Moon that you view in the sky each month, except these views of the Moon are taking place over a 4-hour period instead of the 29.5-day cycle that it takes for the Moon to go from "full moon" to "new moon", and back to "full moon". At the bottom of this composite photograph (6 o'clock position), the moon was completely in the Earth's shadow, creating a total lunar eclipse.

Unlike solar eclipses, lunar eclipses are completely safe to watch. You don't need any kind of protective filters. It isn't even necessary to use a telescope.

Photo 1: My first photo of the Moon

Photo 2: Composite image showing time-lapse photographs of a lunar eclipse

The most efficient way to take many high magnification images over a short period of time is with the use of a webcam that has been modified to replace the eyepiece of a telescope.

IMAGING THE LARGE PLANETS

The next step in my astrophotography learning curve was imaging large planets. The two largest planets in our Solar System are Jupiter and Saturn. Although you can use the "hold the camera up to the telescope eyepiece and take a photograph" technique that I described earlier, to get a more detailed image you need to correct for the turbulence created by looking through Earth's atmosphere. Planets, even the largest like Jupiter and Saturn, appear like pin-point stars from Earth. In fact, often what people believe are very bright stars are really planets in the night time sky. Remember the nursery rhyme "Star light, star bright, first star I see tonight, I wish I may, I wish I might, have the wish I wish tonight" – well that star you may have wished upon was most likely a planet. In fact, that star was probably the planet Venus, Saturn, or Jupiter. To see a planet appear larger than a star, you need a telescope with very high magnification. This very high magnification, often 200x or more, distorts the image and magnifies atmospheric turbulence. One way to create a detailed image and minimize distortion is to take many photographs and stack (digitally place on top of one another) the sharpest images. An added challenge to this technique is that the planets are rotating. Over several minutes, a planet could rotate enough that "stacking images" would create a blurry final image because the planets change in rotational position.

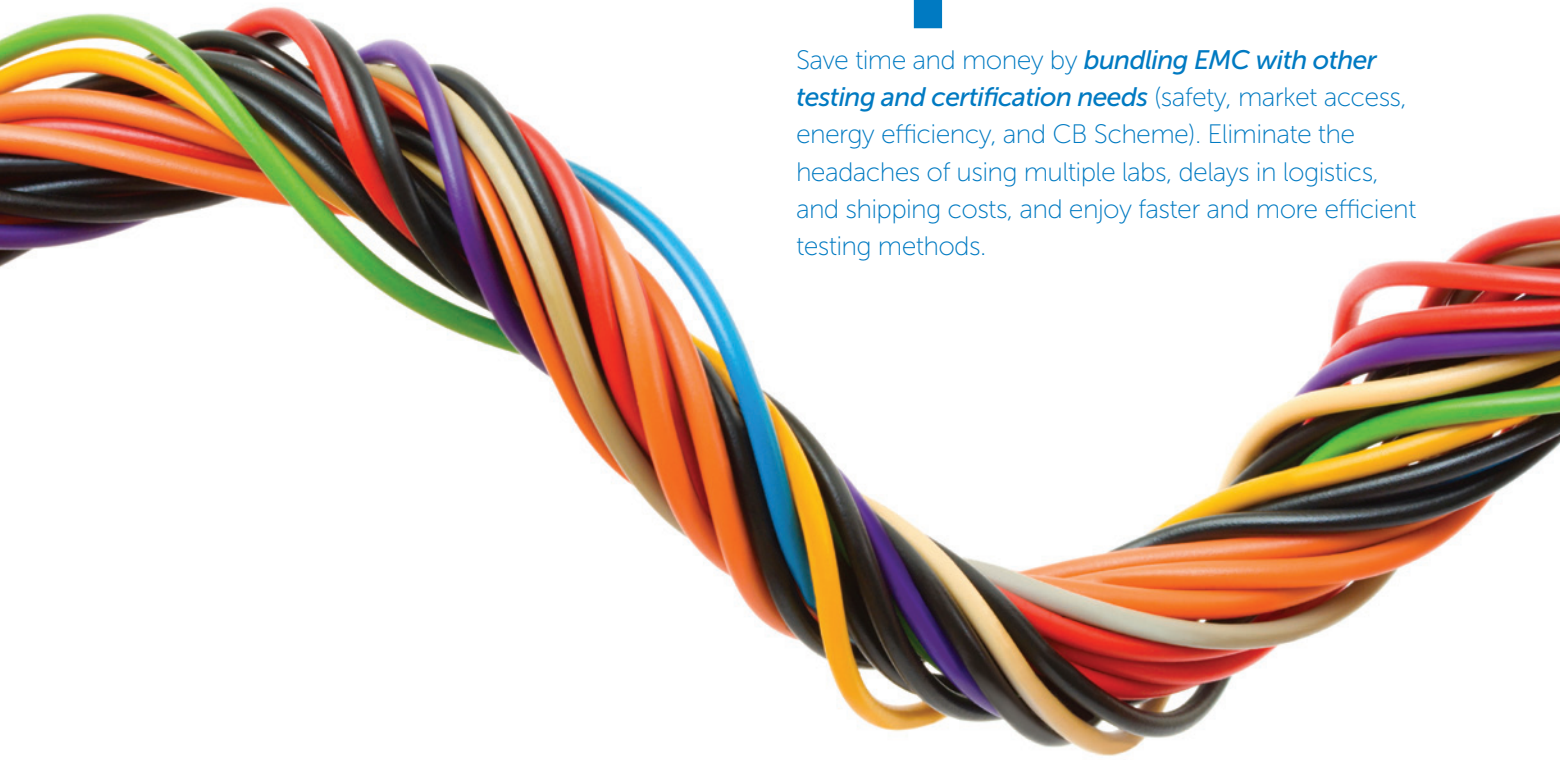
The most efficient way to take many high magnification images over a short period of time is with the use of a webcam that has been modified to replace the eyepiece of a telescope. The advantage of shooting video with a webcam, instead of still images with a camera, is that you can capture many (often 10 to 30) frames-per-second. Because our atmosphere (which is the air that you look through when you view with a telescope) is constantly changing, brief periods of exceptionally calm conditions can be captured with this webcam video technique. Then, using computer software, the best (most sharp) frames from the video can be stacked to form still images that rival the best images taken from professional telescopes and camera equipment only a decade ago.

I used this technique to image the planet Saturn. Saturn is the sixth planet from the Sun, and the second largest planet in the Solar System after Jupiter. Along with the planets Jupiter, Uranus, and Neptune, it is classified as a gas giant planet, which means it is comprised mostly of hydrogen. It is believed that a small core of rock and ice lies at the center of the planet. In diameter, Saturn is almost 10 times the size of Earth. In Roman mythology, Saturn is the god of agriculture and is the root of the English word "Saturday".

Saturn's system of rings, consisting mostly of ice particles with a smaller amount of rocky debris and dust, are visible with a small telescope. These rings are huge, they would cover two-thirds the distance from the Earth to the Moon. Saturn's atmosphere consists of bands of clouds, similar to the planet Jupiter, that can be seen on a clear night with a reasonable (6-inch aperture or more) size telescope. One interesting thing about Saturn is that it is less dense than water – this means it would float on top of a very large body of water. Saturn is great to observe because its

Photo 3: Aligned and stacked image of Saturn

Bundle Up



Save time and money by ***bundling EMC with other testing and certification needs*** (safety, market access, energy efficiency, and CB Scheme). Eliminate the headaches of using multiple labs, delays in logistics, and shipping costs, and enjoy faster and more efficient testing methods.

Product Safety Testing and Certification

Product safety testing assures consumers what they are buying is safe and compliant with applicable requirements. We offer expert third-party testing to almost any product safety standard, including ANSI/UL, ASTM, CSA, EN, IEC, ISO, and NFPA. Our laboratories are recognized by major accreditation bodies, including OSHA (NRTL), Standards Council of Canada, IECEE, FCC and more.

EMC Testing

TÜV Rheinland provides the capacity, proximity and engineering resources to streamline your EMC compliance testing process for any market you want to reach. Our Mobile EMC truck can perform in-situ testing at your site for larger, complex systems.

Market Access

Gain quicker access to global markets with our streamlined and timely solutions. Our International Approval experts will get you through the mryiad of complex regulations, regional interpretations and any obstacles presented by a regulatory authority. We will obtain all the necessary certifications for you.

For 140 years, TÜV Rheinland has been helping its clients meet their test and compliance needs quickly, efficiently and reliably. We have the experience, resources and talented professionals you need, as a one-stop testing partner, for all your EMC, Telecom, Market Access or Product Safety needs.

Visit us at Booth #301

Contact us today to learn more
1-TUV-RHEINLAND
(1-888-743-4652)
www.us.tuv.com

TÜVRheinland®
Precisely Right.

rings make it so recognizable – it is probably one of the most photographed planets in our Solar System.

The image shown here is an "aligned and stacked" image from the best 67 of 445 frames of video (Photo 3). Very little other post-processing was done to this image, other than some sharpening. Several of Saturn's atmospheric cloud bands are clearly visible as well as, of course, those magnificent rings.

This is an image I took of the planet Jupiter (Photo 4). Jupiter is the fifth planet from the Sun and is the largest one in our Solar System. It is also the fourth brightest object in the sky (after the Sun, the Moon and Venus). It has been known since prehistoric times as a bright "wandering star". If Jupiter were hollow, more than one thousand Earths could fit inside. It also contains more matter than all of the other planets combined. Colorful latitudinal bands, which are atmospheric clouds and storms, illustrate Jupiter's dynamic weather systems. The wind speed in the upper atmosphere of Jupiter is believed to exceed 400 MPH.

Jupiter is just about as large in diameter as a gas planet can be. If more material were to be added, it would be compressed by gravity such that the overall radius would increase only slightly. A star can be larger only because of its internal (nuclear) heat source which pushes out from the center of the star in a tug-of-war against gravity. To become a star, Jupiter would need at least 80 times more mass than it currently has.

The image shown here is an "aligned and stacked" image from the best 256 of 607 frames of video. Many of Jupiter's atmospheric bands are clearly visible. I always enjoy looking at Jupiter through my telescope and sharing this giant "gas" planet with others because the atmospheric bands are so easy to see and they change from night to night. Another great feature of observing Jupiter is that on most nights at least a couple of its moons are easy to spot orbiting the planet. One of Jupiter's moons (the moon "Io") can be seen in this image – it looks like a small speck at about the 9 o'clock position relative to Jupiter.

Photo 4: Aligned and stacked image of Jupiter

IMAGING DEEP-SKY OBJECTS

Graduating from imaging "bright objects" (like the Moon and large planets) to imaging "deep-sky objects" (like nebula and galaxies) is like the difference between going for a walk and running a marathon. Deep-sky objects cannot be seen without the aid of a telescope, and even then they are often so faint that the human eye lacks the sensitivity to see what can be revealed from a long-exposure photograph. The exposure time for most daytime photography is measured in fractions of a second. The long exposure that I use to image deep-sky objects is measured in minutes and hours. Long-exposure imaging of faint deep-sky objects present several challenges, four of which are:

- a camera that can image faint objects over long periods of time,
- determining the camera's focus when the object being imaged is too faint for the human eye to see,
- aiming the telescope/camera at objects that are too faint for the human eye to see,
- accurately tracking the sky while the camera is imaging.

Let's discuss how we tackle each of these challenges.

THE CAMERA

As I mentioned at the beginning of this article, my entrance into astrophotography coincided with the digital camera revolution. This is important because film is not intended for long exposures. With the normal exposure times used for film, the intensity of the light and the duration of the exposure determine the brightness of the photograph. In simple terms, the relationship between the aperture and shutter speed is predictable. At very low light levels and long duration times, an effect known as reciprocity failure occurs. This is when increasing the exposure time does not result in the exposure that is expected. Reciprocity failure has a large impact on film-based astrophotography. To add to


Our expertise takes you to the top.
EMC solutions from Rohde & Schwarz.
We provide everything you need for development, precompliance and compliance measurements to ensure successful EMC certification.
Exceptionally fast EMI test receivers
Efficient diagnostic tools for detecting EMI
EMC software packages for interactive and fully automatic measurements
Wide range of accessories for performing EMI measurements
Compact and modular broadband amplifiers
RF shielded chambers
Complete EMC test systems
For more information, visit:
www.rohde-schwarz.com/ad/emc
Please visit us at the
IEEE EMC
in Denver, Colorado
hall A, booth 701
ROHDE&SCHWARZ

this challenge, the spectrum of light emitted from many deep sky objects are outside of the sensitivity curves of most film. These film-based issues do not exist when using the sensors in digital photography. Today's digital camera sensors have the benefit of acting like a bucket that collects photons (light) - the longer the exposure, the more light (color and details) that's captured and displayed in the photograph. The relationship between the aperture and shutter speed is predictable over long periods of time. On the other hand, digital imaging sensors do have their own challenge called dark current. Dark current is the relatively small electric current that flows through an imaging sensor even when no photons are striking the sensor. This appears as noise in the image. However, this dark current and other noise in the image can be minimized by cooling the sensor and by using a technique called dark frame calibration, which will be described later in this article.

There are several companies that make specialized cameras designed specifically for astrophotography. The one I use is made by a company called Quantum Scientific Imaging (QSI). My QSI camera uses an 8.3 mega pixel CCD image sensor. The sensor in the camera can be cooled to 45°C below the ambient temperature to reduce the noise in long exposures. The camera attaches directly to the telescope where the eyepiece is normally located. In this way, the telescope becomes a very big lens for the camera.

Focusing the camera can be a difficult process because the deep-sky image being photographed cannot be seen until after a long exposure, typically at least a minute, is taken. Achieving focus is accomplished by turning the focus knob on the telescope to move the camera whichever way is appropriate to achieve focus. Because the deep-sky image cannot be seen, I focus the camera on a nearby star that is usually in the frame of the deep-sky object being imaged. I take an image of a star, and use a technique that measures the width of the star by determining how many pixels on the imaging sensor are being illuminated at half the peak value of the light (photons) from the star. This is called measuring the "full width at half maximum" (FWHM) of the star. The lower the value, the better the focus. Think about starlight illuminating an array of imaging pixels; when the least number of pixels are illuminated, maximum focus is achieved. I have automated this process using a commercially available product called RoboFocus which is made by a company called Technical Innovations. RoboFocus uses a microprocessor controlled stepping motor that attaches to the telescope focus knob. Using software and a focusing algorithm, the FWHM of the star is measured and focus is adjusted until the optimal focus is achieved.

THE TELESCOPE MOUNT

Now would be a good time to introduce one of the most critical pieces of equipment for astrophotography – the telescope mount. The telescope mount is at the core of the imaging configuration. Taking photographs of deep-sky objects requires a telescope mount that can accurately track the sky over long periods of time and very long exposure time with a camera. It is used to provide a stable base to mount the optical tube (the actual telescope), point the optical tube at the object to be viewed, and accurately track the sky while the object is being imaged.

First let me discuss the importance of providing a stable base by way of the telescope mount. The mount must be able to support the payload of the optical tube (in my case there are several of them), as well as the camera,

and accurately track the sky. I chose a German equatorial-type mount called a Paramount ME which is made by a company called Software Bisque. The Paramount ME has a payload capacity of 150 lbs (68 kg) and can accurately track the sky with an accuracy of several arc-seconds. To understand what this means, I need to explain image scale. Picture the entire dome of the night time sky as the face of a clock. The clock is divided into hours, minutes, and seconds. Much like this clock example, the celestial dome that makes up the night time sky above you is divided into degrees and each degree is comprised of arc-minutes and arc-seconds. The best case ideal scenario, assuming a flat surface and no obstructions, would be a 180 degree view from horizon to horizon. There are 60 arc minutes in each degree, and each arc minute is made up of 60 arc seconds. With this in mind, celestial objects in the night time sky can be referred to as having a specific size as measured in arc minutes or arc-seconds. To get a sense of just how small a slice of the sky an arc-second represents, take a U.S. quarter, hold it on edge so you are looking at its width against the sky, then move that quarter 3 miles away – the width of a U.S. quarter, as seen from 3 miles away, is one arc-second! As an example, a full moon covers approximately 0.5 degrees of sky, which is 30 arc-minutes or 1,800 arc-seconds. Another example would be a double star system, where two stars are gravitationally bound to each other. A good example is Polaris, the North Star. The main bright star, Polaris A, is separated from small faint star, Polaris B, by 18" (eighteen arc seconds). Image scale is the size of an image on the imaging sensor – usually measured in arc-seconds. This explains the importance of accurately tracking the sky as stars, which appear as pin-points and typically have an image scale of a few pixels, will quickly become oblong and then streak if there are guiding errors. This becomes less of an issue at lower magnifications or wider fields of view, both of which would have a higher image scale.

Without going into a complicated discussion of polar alignment, let's just say that parts of the telescope must be pointed precisely at Earth's North Celestial Pole. The Earth rotates around its poles (north and south) making one revolution each day - approximately 24 hours. This rotation can be seen by noting the change in position of celestial objects in the sky. Most notable during the day is our Sun, and in the night our Moon. The stars and other celestial objects move across the sky in much the same way as the sun and moon. For people in the northern hemisphere, there is one point in the sky that doesn't appear to move. It doesn't appear to move because this is the North Celestial Pole, the point in the sky around which all the stars seen from the northern hemisphere rotate. The North Star, also called Polaris, is located almost exactly at this point in the sky. If you go out at night and find the North Star you will notice that it doesn't move during the course of the night, while all the other stars do move; they rotate counter-clockwise around the North Star (from east to west – think about the sun rising in the east and setting in the west). It's similar to spinning a basketball at the end of your finger; the point where your finger contacts the basketball is almost stationary as the rest of the ball rotates around it. This alignment of the telescope with the North Celestial Pole is critical to taking long exposure photographs of the sky.

Once the telescope system is polar aligned, I then align the mount to its geographic location. This is done by pointing the telescope to several known stars in the sky. The mount has a database of celestial objects and can "learn" its exact location by referencing this database with the position of

the stars. Now the mount can point the telescope to any object in the sky that I want to image using a software program called *The Sky* to aim the telescope, by way of controlling the mount, to the position in the sky that I want to photograph. Once the program has aimed the telescope, I take some short (about 2 to 5 minute) exposures to confirm that it's pointed in the right place and to frame the object in the center of the photograph. It's important to remember that many of the celestial objects that I photograph are so faint that you can't see them visually when you look through a telescope, so this process ensures that I am imaging the object of interest. Once confirmed, I can increase the exposure times to reveal more detail.
and camera assembly

THE OBSERVATORY

For several years I did my astrophotography from the driveway of our home in Groveland, CA. My imaging session would begin just before sunset when I rolled out the telescope equipment. There are many pieces to the setup that I use – the telescope mount, the imaging telescope, the guiding telescope, the camera, adapters, and all the other electronic equipment needed to ensure precise tracking of the sky. Once I roll out and set up the nearly 200 pounds of equipment and the sky is dark enough to see some stars, I begin the process of aligning the telescope system to the sky. The alignment of the telescope with the sky is critical to taking long exposure photographs of deep-sky objects. Once the telescope system is aligned, I need to teach the mount its geographic location. This is done by pointing the telescope to several known stars in the sky. This entire "setup" process and focusing of the camera takes about 2 ½ hours (Photo 5). Breaking down all the equipment at the end of my

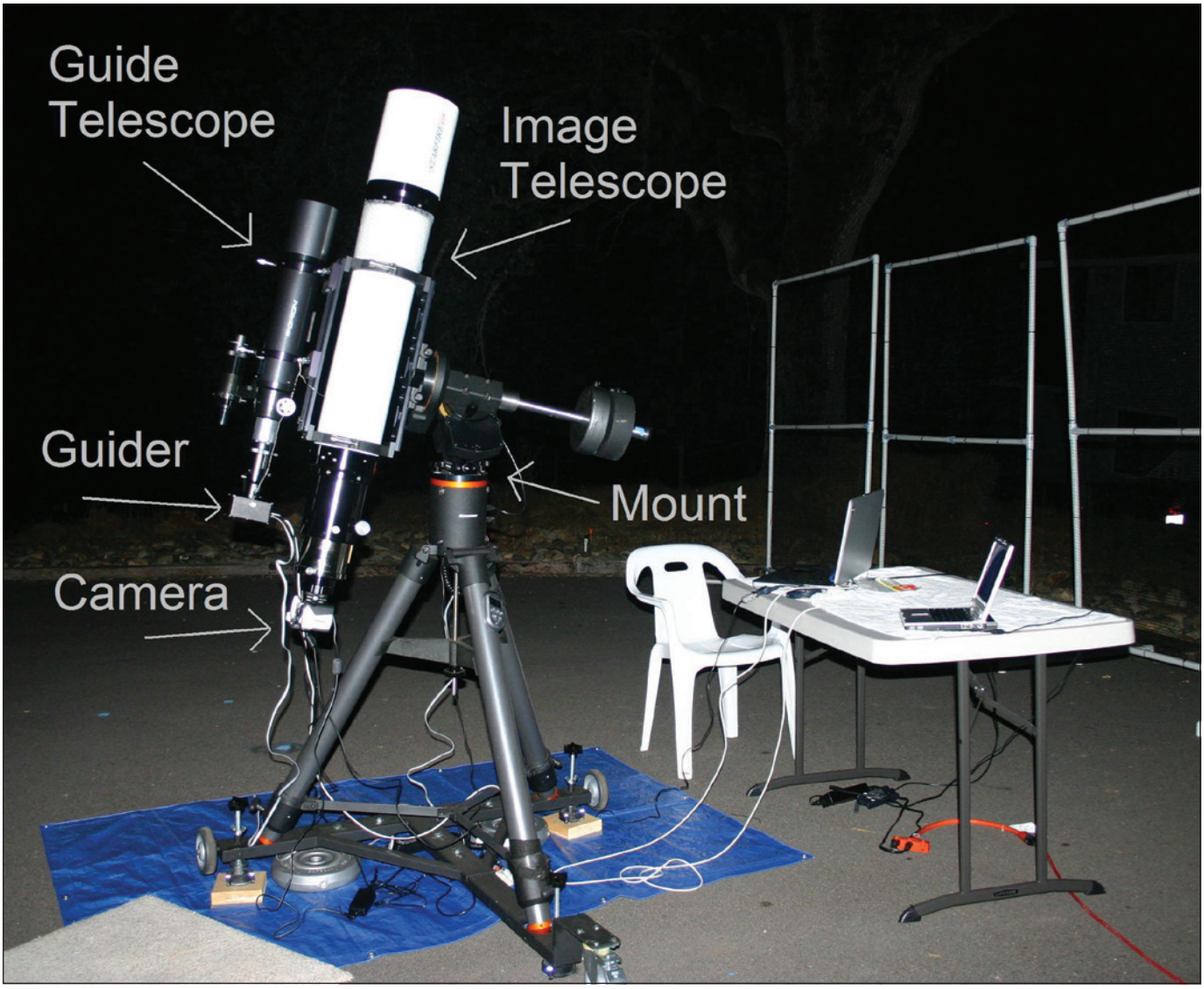


Photo 5: Basis telescope and camera setup in driveway

Verifying EMC performance is one thing. Diagnosing the cause of EMI is quite another.

When you find a device out of EMI compliance, now you can also understand why. Because the new Agilent receiver is also an X-Series signal analyzer, loaded with diagnostics to show what's happening.

That's thinking ahead. That's Agilent.

Agilent N9038A MXE EMI Receiver

- CISPR 16-1-1 2010 compliant
- Built-in X-Series analyzer runs applications
- Intuitive interface and graphical displays
- Upgradable for long-term flexibility

Download Competitive Comparison and App Note:
Reduce Verification Time with Fast Scanning.
www.agilent.com/find/AgilentEMIreceiver

u.s. 1-800-829-4444 canada 1-877-894-4414

Agilent Technologies

imaging session, typically about 4 AM the following morning, takes about 1 hour. Assuming that I can't leave the telescope setup outside for several nights, this is a 3 ½ hour process each and every time that I image the sky.

With a permanent setup, an observatory, this 3 ½ hour setup/breakdown is unnecessary. The telescope is attached and aligned on a permanent pier. The entire setup process with an observatory typically takes less than 30 minutes and there is no breakdown at the end of the evening - you simply close the observatory dome.

Lisa and I began looking for a location to build an observatory in 2006.

The site where our home is built in Groveland is too close to the golf course and the lights from our neighbors. We decided that the right observatory site for us would include a balance of dark skies, meaning minimal light pollution from neighboring sites, and proximity to our existing home in Groveland - ideally no more than a 30 minute car ride. After about a year of checking dozens of potential building sites, we purchased a 10 acre plot of land. It has a 360 degree panoramic view of the sky, minimal light-pollution, and is less than 5 miles from our existing home in Groveland. As an added bonus, the daytime views are spectacular - which led us to modify our plans for an observatory, to include a small studio-type house.

To read more about the construction of our observatory visit the *In Compliance* website at http://www.incompliancemag.com/pavlu_observatory.

THE TELESCOPES

The main telescope, referred to as the imaging scope, attaches to the mount. The imaging scope is where I attach the imaging camera. Because of the precise tracking requirements, I also use another telescope that is attached to the imaging scope. This telescope is called a guide scope. I use the guide scope to correct any tracking errors by focusing on a star, called a guide star. By placing a guide star in the cross-hairs of a special eyepiece, small adjustments

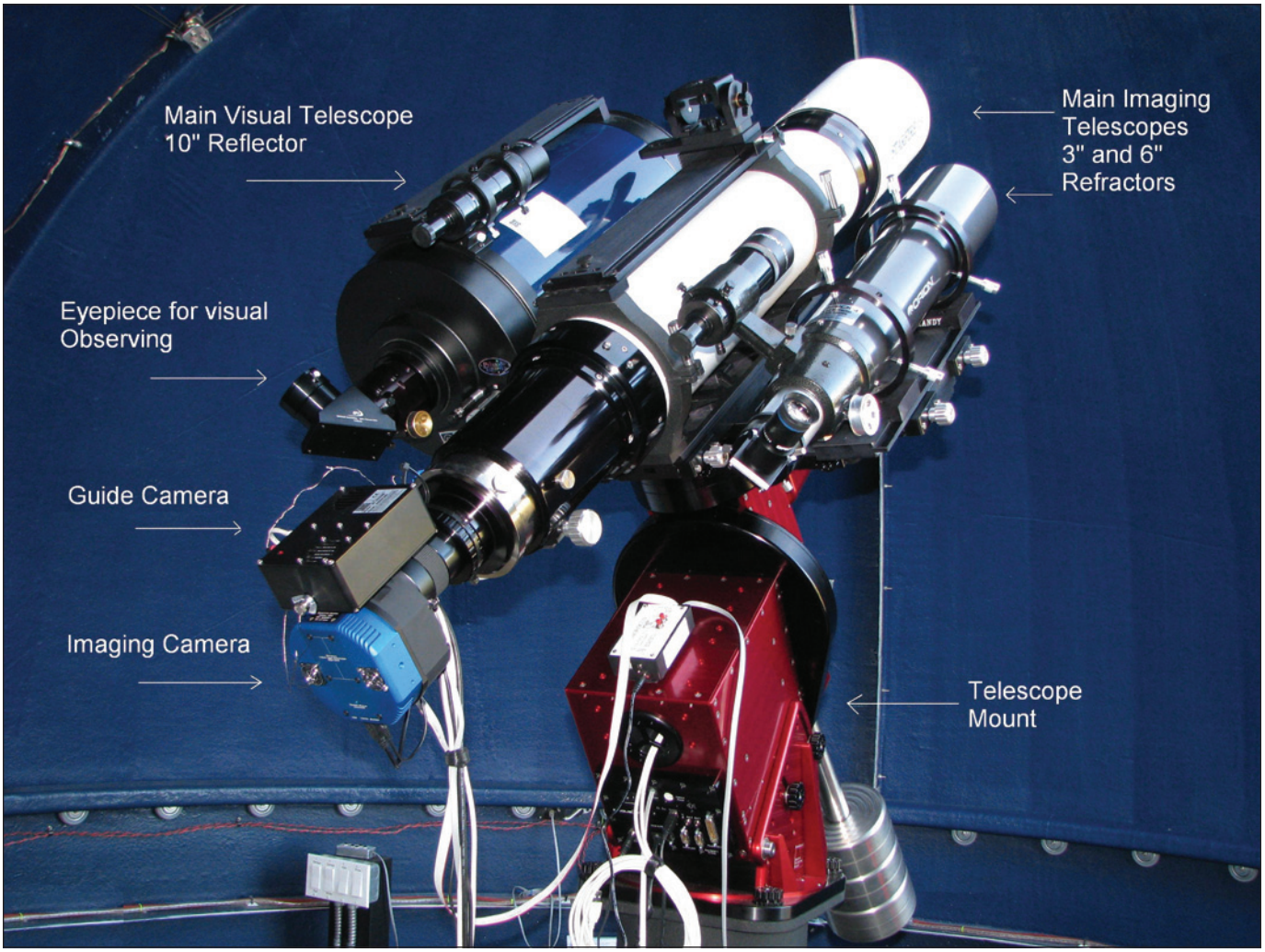


Photo 6: Detail of mounted telescope and camera

can be made to the mount tracking. This is a very tedious process as these small adjustments are made several times a minute while the photographic exposure is being completed. I can guide manually by making the adjustments myself, or I can use an additional camera attached to a computer to auto-guide the telescope mount by sending electronic signals that make the small corrections needed to ensure precise tracking of the sky.

Printed with this article is a photograph of my astrophotography setup (Photo 6). The (red) telescope mount (Paramount ME), which moves the telescope and tracks whatever I happen to be photographing, is attached to the pier that penetrates our observatory floor. Only the very top of the pier can be seen in this photograph. There are two main imaging telescopes, a 3" and a 6" refractor. In this photograph, the image and guide cameras are attached to the larger 6" (white) refractor. I also have a 10" (blue) reflector telescope attached to the mount that is used as a visual telescope. This visual telescope has an eyepiece that allows observing without disturbing the imaging camera setup.

THE POWER OF EXPOSURE TIME

Once it's dark enough and the camera is focused, it's time to take some photographs. I take many separate photographs with exposure times as short as 15 seconds and as long as 30 minutes. Then, all the individual photographs are aligned and digitally "stacked" one on top of another to create the final image. It is this long exposure alignment and stacking technique that creates an image with the level of detail visible in the deep-sky images accompanying this article. Depending on how faint the object is that I'm photographing, the total exposure time of the images that I stack have been over 16 hours. In this case, I will take photographs over several evenings to create the final image. Processing all the individual images to create the final image typically takes 60 to 80 hours.

People are often surprised when they don't see images like those I've shared with this article when they look through a telescope. While few experiences can replace the "wow" factor of seeing the planet Saturn's rings or the Orion Nebula through a telescope for the first time, the human eye is simply no match for the light gathering ability of a digital camera. Now don't get me wrong, I'm not suggesting that we replace all our telescope eye pieces with electronic displays. I'm simply stating that each technique has its merits and drawbacks.

The human eye contains two types of photoreceptors, rods and cones. The rods are more numerous (some 120 million) and are more sensitive than the cones. However, rods are not sensitive to color. This is why you typically see shades of gray, instead of color, in low light conditions. Try it yourself. Take a colorful picture outside at night and see how little color information is detectable. Today's digital camera sensors don't have these low-light color restrictions. You can think of a digital camera sensor as a bucket that collects photons (light) - the longer the exposure, the more light (color and details) that's captured and displayed in the final photograph.

One night sky feature popular with both beginning and experienced stargazers is Pleiades, also known as the Seven Sisters for the seven stars that can be seen with excellent eyesight. The Pleiades are a prominent sight during the winter as viewed in the northern hemisphere and to the naked eye appears as a small cluster of stars.

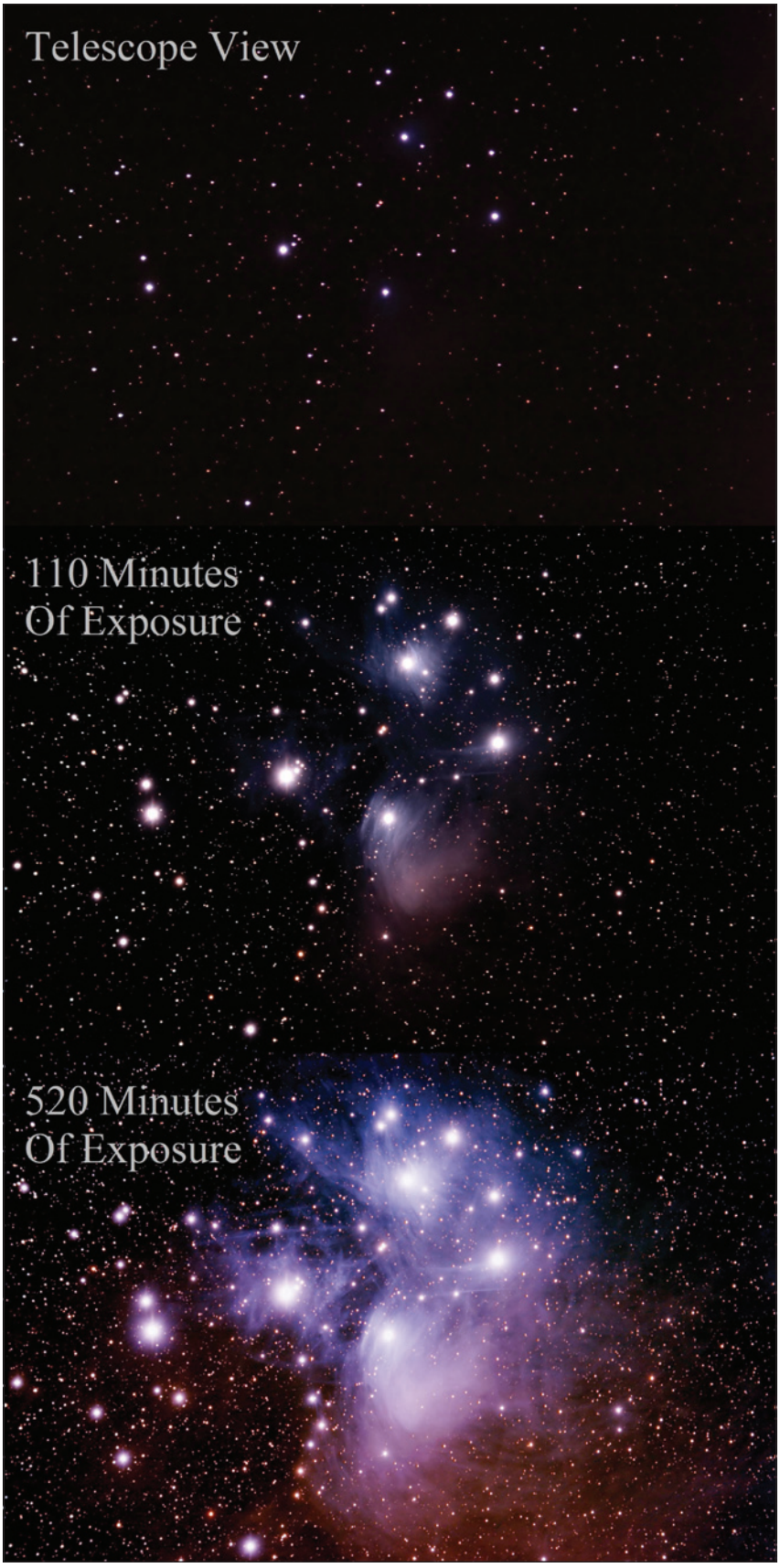


Photo 7: Illustration of various exposure times

Pleiades is about 400 light-years from Earth. If you have less than excellent eyesight, Pleiades may look more like a small fuzzy patch, about the size of a dime at the end of your fully extended arm. In addition to the stars, Pleiades contains a reflection nebula. Reflection nebulae are clouds of dust which are reflecting the light of a nearby star or stars, similar to how the headlights on a car illuminate fog. Thus, the color shown by reflection nebulae is similar to that of the illuminating stars.

I've included three images of Pleiades here (Photo 7). The first image illustrates what you would expect to see when viewing Pleiades through a telescope. The most visible feature is the stars, as little, if any, of the reflection nebulosity can be seen. The second image illustrates an image of Pleiades after 110 minutes of exposure. Eleven individual images, 10 minutes of exposure each, easily reveal the nebulosity. The third and final image reveals Pleiades in all its glory. Fifty-two individual images, 10 minutes of exposure time each, taken over 3 separate evenings. These 520 minutes of exposure reveal the complex nature and color of Pleiades with all its reflection nebulosity.

These three images of the same beautiful deep sky object show vastly different detail. At one end of the spectrum, the telescope view is the real-time "being one with the universe" personal experience of the light that left Pleiades nearly 400 years ago. At the other end of the spectrum is the image created from nearly 8 ½ hours of exposure time, with all the beauty and color revealed thanks to the power of exposure time.

PROCESS FLOW

Photographing deep-sky objects is all about exposure time. As I mentioned, I take many separate photographs with exposure times as short as 15 seconds and as long as 30 minutes.

Then, all the individual photographs are aligned and digitally "stacked" one on top of another to create the final image. In order to do this effectively, I follow a strict process when creating a final image. Let's assume that I've captured images of a deep-sky object over several nights. The first thing I need to do is calibrate these individual images. Calibrating the images removes the noise associated with the digital imaging sensor and the optical imaging path. I perform three types of calibrations on each photograph:

1. flat-frame calibration
2. bias-frame calibration
3. dark-frame calibration.

Flat-frame calibration is used to minimize imperfections in the optical path. In the case of my photographs, the optical begins when the light enters the telescope and ends when the light hits the imaging chip in the camera. Flat-frame calibration is performed by taking a photograph of an evenly illuminated neutral surface so foreign objects, like dust specks, can be digitally subtracted. This calibration also compensates for any vignetting, which is when edges of the photograph are darker than the center of the photograph.

Bias-frame calibration is used to minimize an offset (bias) when a pixel is read from a digital camera. This is caused by the readout noise that is produced by the electronics that are reading the pixel values. The bias for a particular camera is generally constant over a long period of exposure time. A bias frame is a short-length exposure with the shutter closed. This bias frame will have slightly different pixel values but, except for a small amount of noise, the value for any one pixel will be consistent from image to image. Since the bias is consistent from image to image, it can be subtracted from the deep-sky images.

Dark-frame calibration is used to minimize the noise that accumulates in camera sensors during a long exposure. This noise increases with exposure time and temperature and has a random component. This means that several dark frames must be taken at the same temperature and exposure times as the deep-sky images, except that dark frames are taken with the light path blocked – basically they are taken with the lens cap on. These dark frames are averaged and subtracted from each of the deep-sky images.

Once each of the images is calibrated, they need to be aligned. Since each image will be digitally stacked one on top of another, they must be perfectly aligned so pixels will add appropriately. Image alignment is performed by choosing several features in a reference image, usually stars, so all the other images can be scaled and rotated to match the exact positioning in the reference image. Then, after calibration and alignment, the images can be digitally stacked to bring out details that are not visible in each individual image.

PHOTOGRAPHY & ENGINEERS

Given my background, I have many friends that are engineers. Quite a few of them are compliance engineers. I've noticed that many of them have photography as a hobby ... and I use the term "hobby" lightly, as many of them would be considered professionals except that they don't make a living from their photography. My friend Tom, mentioned at the beginning of this article, is a compliance engineer and an astro and landscape photographer. My friend Russell is an electrical engineer and a SCUBA (underwater) photographer. My dad, an engineer, shoots nature photography. My friends, Barry, Michael and Gaylon, are both engineers and photographers.

This convergence of engineering and photography is not accident. I think it happens because certain types of photography offers a good balance of technical challenge and creativity. We're all familiar with the distinction between left-brain dominant (logical) and right-brain dominant (creative) people. Let's define casual photography as using a point-and-shoot camera in an automatic setting mode to take photographs that look "pretty", and technical photography as using a DSLR in a manual setting mode to take complex photographs – like the ones explained in this article. Using this explanation, I believe technical photography uses both the left and right side of the brain. I believe most engineers tend to be left-brain (logical) dominant, so technical photography helps to exercise the right side of our brain without being so overwhelmingly creative that it's too foreign to relate to. Whatever it is, I strongly suspect many amateur photographers who take technical photographs also have a technical (e.g. engineer) background. For me personally, there are few other hobbies where I get to use my technical skills to make something that looks "pretty". Hope you have enjoyed the results. Live long and prosper. IN

(the author)

EDDIE PAVLU

was most recently Vice President of Operations at National Technical Systems. Prior to that he was President and CEO of Elliott Laboratories. He has a Bachelors and Masters degree in Electrical Engineering, and has been in executive management for the past 16 years. He is a senior member of the IEEE and a member of the EMC Society. Outside of business, he is an amateur astronomer and astrophotographer, with photographs published in several publications, including *Astronomy Magazine*.

Excerpts from Eddie's Deep-Sky Photo Album

Here are a few of the beautiful images Eddie Pavlu has captured during the decade of amateur astrophotography he describes in the article on page 54 of this issue (**Reaching for the Stars from the Lens of a Telescope**). The common fascination between things electrical and things astronomical is undeniable for so many of us that we are sure you will look forward, as we do, to the second part of Eddie's article which details the creation of a home observatory and the techniques that allowed him to create these images.

THE HORSEHEAD NEBULA

The Horsehead Nebula region is located in the constellation Orion, is approximately 1,600 light-years away, and spans about 5 light-years. A nebula can make itself visible by glowing as "emission nebula"; that is, by scattering light from stars within it as "reflection nebulae" or by blocking light from things behind it as "dark nebula".

There are several objects in this image. The dark nebula that forms the Horsehead itself is known as Barnard 33. The horse-head feature is dark because it is an opaque dust cloud which lies in front of the bright red emission nebula. The red background is the emission nebula IC 434. The emission nebula's red color is caused by electrons recombining with protons to form hydrogen atoms. The blue nebula just below and to the left of the Horsehead is the reflection nebula NGC 2023. The reflection nebula's blue color is caused by blue star light that is reflected off the nebula. After several hundred thousands of years, the internal motions of the nebula will alter its appearance and will most likely no longer resemble a horse-head. I created this image by stacking 92 images of 5- and 10-minute exposures taken over 3 nights. The total exposure time is 690 minutes.

THE HELIX NEBULA

The Helix Nebula is an example of a planetary nebula created at the end of the life of a Sun-like star and is occasionally referred to as “The Eye of God”. A nebula is a cloud of gas and/or dust in interstellar space. A planetary nebula is when the outer gasses of a Sun-like star are expelled into space. The remnant central stellar core, destined to become a white dwarf star, glows in light so energetic it causes the previously expelled gas to glow. The Helix Nebula, given a technical designation of NGC 7293, lies approximately 450 light-years away and spans about 1.5 light-years. I created this image by stacking 42 images of 5-, 10-, 15-, and 20-minute exposures taken over 4 nights. The total exposure time is 415 minutes.

THE EASTERN VEIL NEBULA

The Eastern Veil Nebula, designated NGC6992 and sometimes called the Bridal Veil Nebula, is located in the constellation Cygnus, is approximately 1,400 light-years away, and spans about 30 light-years. This nebula is the remnant of a supernova explosion that occurred about 10,000 years ago. A supernova is an explosion caused when a massive star, at least 8 times the Sun's mass, dies and collapses. The outer layers of the exploding star are blasted out in a cloud. This expanding cloud, visible long after the initial explosion fades from view, forms a supernova remnant. I created this image by stacking 12 images of 10- and 20-minute exposures. The total exposure time is 151 minutes.

THE ANDROMEDA GALAXY

The Andromeda Galaxy, designated M31, is approximately 2.9 million light-years away. The light from Andromeda is created by the hundreds of billions of stars that compose it. The Andromeda Galaxy is our nearest large neighbor galaxy. Andromeda is about twice as big as the Milky Way, our home galaxy. While most galaxies are rushing away as the universe expands, Andromeda is the only big spiral galaxy moving towards the Milky Way. The best explanation is that the two galaxies are in fact a bound pair in orbit around one another and are falling back together. One very plausible scenario puts them on a collision course in about 3 billion years. I created this image by stacking 6 images that range from 2- to 15-minute exposures. The total exposure time is 47 minutes.

THE LEO TRIO GALAXIES

This small group of galaxies consists of the Messier objects M65 (NGC 3623), lower right, and M66 (NGC 3627), lower left, along with the edge-on spiral galaxy NGC 3628, upper left. These three galaxies form a rather attractive triplet in the Leo Constellation and are referred to as the Leo Trio Galaxies. These galaxies are about 35 million light-years away. I created this image by stacking 14 images of 5 and 10-minute exposures. The total exposure time is 110 minutes.

Diamond Jubilee: The 60th Anniversary of the Use of the 41 Inch Rod Antenna in Military EMI Testing

BY KEN JAVOR

This year marks not only the title anniversary, but arguably also that of the beginning of the modern era in vehicle electromagnetic interference (EMI) testing.

Radiated emission (RE) testing of equipment to be used on self-contained vehicles is performed at one meter or less versus testing at a distance of three meters or more for equipment designed for use in homes, offices and factories. By modern era is meant the realization that for such near-field RE measurements to be useful, the sensor/pickup/antenna must closely model the actual victim protected by the EMI standard in question, in physical appearance, orientation and separation from the victim. Prior to 1953, various sensors were used somewhat indiscriminately, with small attention paid to repeatability and correlation between equipment-level RE measurements and vehicle-installed electromagnetic compatibility (EMC).

The 104 cm (41 inch) rod antenna is conceptually one of the simplest devices in our arsenal of measurement tools, but it is a sad fact that it is poorly understood today.

Most EMC engineers understand intuitively that the rod antenna sums the electric field components parallel to its length, and the radio frequency (rf) potential available at the base is one-half the potential difference between the rod base and top. It is less well-known that the potential at the rod base is not measured as an absolute, but

like any potential measurement, the measurement is a potential difference - in this case, the potential difference is between the rod base and the potential of local ground near the base, meaning the counterpoise. The counterpoise potential is often considered to be a zero potential, but in fact it is not, by virtue of being exposed to the same field as the rod. It is this latter fact, amongst others, which is addressed by the MIL-STD-461F rod antenna configuration change, and ongoing efforts to develop MIL-STD-461G.

After a historical retrospective, misinterpretations and errors, up to and including an unfortunate description in this year's EMC Symposium Record, are reviewed and explained.

The historical discussion is taken largely from a monograph on the same subject available in the "History" section at www.emccompliance.com, and an article by the author entitled, "On the Nature and Use of the 1.04 m Electric Field Probe" [1] - henceforward Javor 2011. Javor 2011 goes into depth on the physics and math of electric field coupling to a 104 cm rod, whereas this article is qualitative and simply references the analytical and test results demonstrated back in 2011. Unless otherwise noted, the test data and test set-up photographs used in this article were borrowed from work done developing Javor 2011.

THE BEGINNING

29 May 1953 was the release date of MIL-I-6181B, "Interference Limits, Tests and Design Requirements, Aircraft Electrical and Electronic Equipment," the first to adopt the use of the 104 cm rod antenna. The first use of the 104 cm rod antenna is explained in NADC-EL-5515, dated 10 August 1955, "Final Report, Evaluation Of Radio Interference Pick-Up Devices And Explanation Of The Methods And Limits Of Specification No. MIL-I-6181B." This report was essentially a rationale appendix for MIL-I-6181B.

Before, during, and after WWII, right up to 1953, standard practice for connecting a communication radio to an antenna made use of unshielded wire that was essentially a continuation of the external antenna (Figure 1). The antenna connection was just as sensitive to rf as the antenna itself, and within the vehicle, it was exposed to

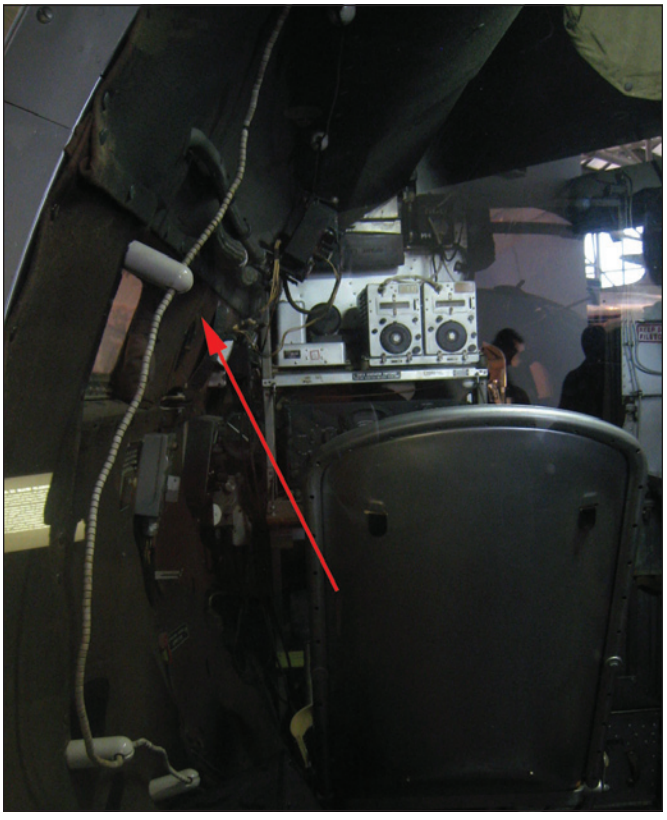


Figure 1: Antenna connection wiring run inside of WWII-era bomber (National Air & Space Museum, Washington DC). The bare wire is covered by steatite beads, which provide the required insulation when the antenna is transmitting. In transmit mode, as much as 5 kV potential was on this wire, at medium and high frequencies!

Figure 2: Separation between unshielded antenna lead and closest adjacent wire bundle (National Air & Space Museum, Washington DC). Wire separation was the only available control on crosstalk in these days of open wires and minute signals in receive mode and extremely dangerous potentials in transmit mode.

numerous sources of radio frequency interference (rfi).

The input impedance of radio mixer tubes of this era was very high, and it was necessary to separate the antenna lead wire from aircraft structure to limit capacitive loading. That is the function of the porcelain standoff highlighted in Figure 1. The high impedance wire was very susceptible to capacitive crosstalk, and pains were taken to keep it separate from other wiring. Notice the separation of the wiring along the top of Figure 2 suspended on the porcelain standoff from other cable assemblies.

The rfi problem was well understood, as evidenced in the Figure 3 drawing excerpted from a WWII-era War Department Technical Order.

The long-term fix for the resultant rfi was to eliminate the unshielded

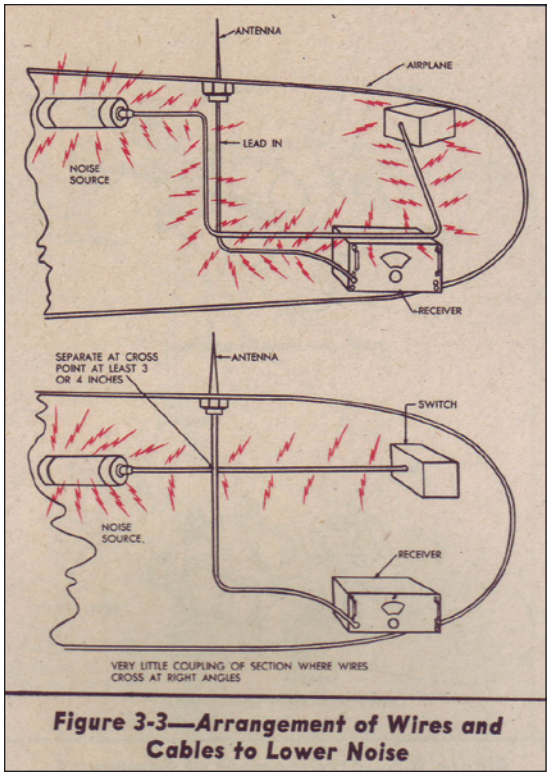


Figure 3: Drawing showing coupling of aircraft internal rfi sources to an internal antenna lead in, and how to minimize crosstalk. It is quite clear that rfi occurs internally to the aircraft, and that coupling to the antenna itself isn't even an afterthought! - from the 1945 "Handbook of Elimination of Radio Noise in Aircraft" which in turn was an update of a similar 1942 publication (United States War Department and the Air Council of the United Kingdom).

antenna lead-in from future procurements. MIL-I-6181B banned such procurements, replacing them with radios compatible with coaxial cable. But there was a very large inventory of the older radios, and the aircraft that had them installed, and so MIL-I-6181B still had to protect (grandfather) those installations. William Jarva, the author of NADC-EL-5515, picked the 104 cm rod antenna as provided with the Stoddart Aircraft Radio Company AN/PRM-1 meter (new at the time) as a reasonable simulation of the unshielded antenna lead-in at frequencies below 20 MHz. Above 20 MHz, a horizontally polarized tunable dipole was used.

Figure 4: Re-enactment of the NADC-EL-5515 set-up used to create the RE limit in MIL-I-6181B in 1953. With this set-up, there was a nearly one-to-one correlation between failing an EMI requirement and causing an EMC problem in a vehicle. Once the problem of open-wire lead-ins had been solved, the correlation was much lower. In fact, MIL-E-6051D, a system-level EMC standard released in 1967 cautioned thusly: "Unless otherwise specified in the contract, subsystems/equipments shall be designed to meet the requirements of MIL-STD-461 and MIL-STD-462. Since some of the limits in these standards are very severe, the impact of these limits on system effectiveness, cost, and weight shall be considered."

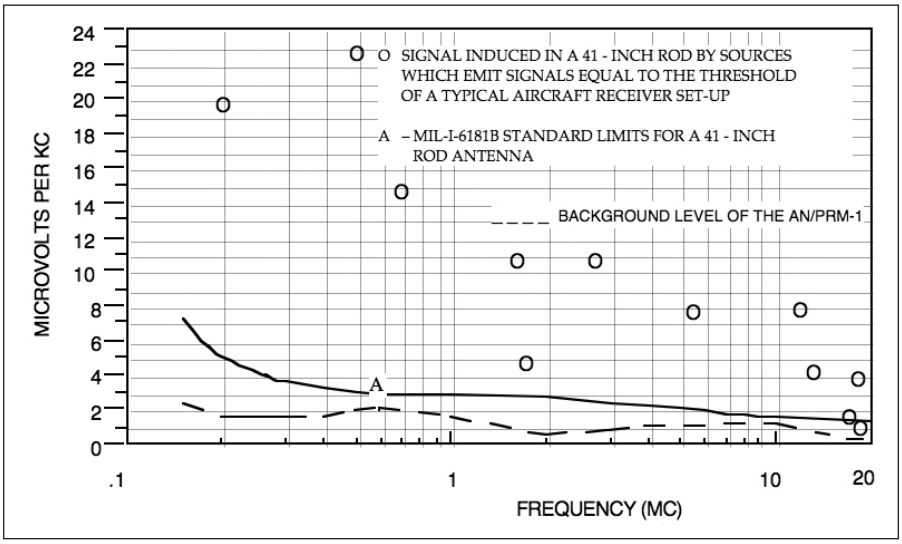


Figure 5: Limit determination for radiated emissions below 20 MHz in NADC-EL-5515 and MIL-I-6181B (note inherently broadband units – all sources used were broadband, reflective of electrical culprits at the time)

NADC-EL-5515 describes a measurement made by Mr. Jarva to develop a radiated emission limit to protect the BC-348Q radio installation. Figure 4 is a re-enactment of this set-up.

A full description of the measurement is to be found in the aforementioned articles. For the purpose of this retrospective, it is sufficient to note that the AN/PRM-1 EMI receiver in the foreground was battery-powered and the only connection to the receiver was a short bond strap to the tabletop ground plane. Further, the 104 cm rod emanates directly from the EMI receiver; there is no intervening cable. In this way, the EMI receiver very closely simulated the period-piece BC-348Q radio placed on the ground plane that was the victim protected by the RE limit. Impulsive noise (represented by the impulse generator) coupled equally to the unshielded antenna lead connected to the BC-348Q and the 104 cm rod antenna. The impulsive noise source was placed equidistantly from the BC-348Q antenna lead and the 104 cm rod antenna, and the separation was one foot, as opposed to one meter today. This reflected the separation achievable between culprit and victim wiring in the aircraft of the time. When rfi was detected by listening to the BC-348Q headset, the meter deflection was noted on the AN/PRM-1 meter, and a limit was built in terms of the rf potential measured by the meter (Figure 5), as opposed to the modern day practice of

Your connector can be an EMI filter, too!

Quick, easy, permanent retrofit with EESeal® FilterSeals

Installs in seconds, no soldering, just push in

Durable, conformal elastomeric body

Meets wide barrage of mil-standard tests

Pin-to-pin & pin-to-shell capacitors, MOVs, resistors, shorts, etc.

AS9100 Certified

nqa. ISO 9001 Registered · ANAB ACCREDITED · nqa. AS9100 Registered

Custom designs to you in just days!

Call for a free sample.

505.243.1423 • www.eeseal.com

Quell

measuring a field intensity. Such a limit is termed "antenna-induced" (dBuV) as opposed to field intensity (dBuV/m). An antenna-induced limit necessarily requires tight specification of the antenna. Modern one-meter military RE limits control field intensity, but still retain control of antenna type, vs. RE measurements specified at three meters or more, which do not. This reflects once again the difference between near and far field measurements.

The following excerpt from NADC-EL-5515 (available from the emccompliance.com history page) explains the physics of the situation in Mr. Jarva's own words:

> "ANTENNA SYSTEMS FOR RADIO INTERFERENCE MEASUREMENTS
> In the frequency range 0.15 to 20 mc, radiating elements, pick-up antennas and distances, generally used for radiated radio interference measurements, are small compared to wavelength. The amount of energy transferred from field to antenna depends on the nature of the signal source and the type of receiving antenna used. For instance, if the radiating interference source is a single, small closed loop of wire, a great deal of current can flow without developing much voltage across the loop. Consequently, a large magnetic component is developed in the induction field in conjunction with a comparatively small electric component. To extract a large amount of energy from such a field, a similar loop antenna, correctly matched to a receiver, should be used as the pick-up device to provide what may be compared to a good impedance match in ordinary circuit theory. If a short rod antenna, sensitive to the electric component of the field, were used as the pick-up device very little energy transfer would result and a situation comparable to a condition of impedance mismatch would exist. When a short rod antenna is the signal source, a large voltage can be developed on the rod, but with very little current flow. Consequently, the field developed is composed of a large electric component and a small magnetic component. In this case, another rod used as a pick-up device would indicate the presence of an intense field, whereas, a loop antenna would give very little indication. Typical radio interference sources in aircraft include the extreme cases described and all other variations. In general, the ratio of the electric to the magnetic components surrounding an unshielded lead will vary directly as the impedance of the load terminating the lead, and the apparent impedance presented to the various pick-up antennas will vary in the same manner. This statement applies to radial and tangential field components as contrasted with the more usual concept of wave impedance encountered in shielding theory, which applies only to the components tangential to the line of propagation.

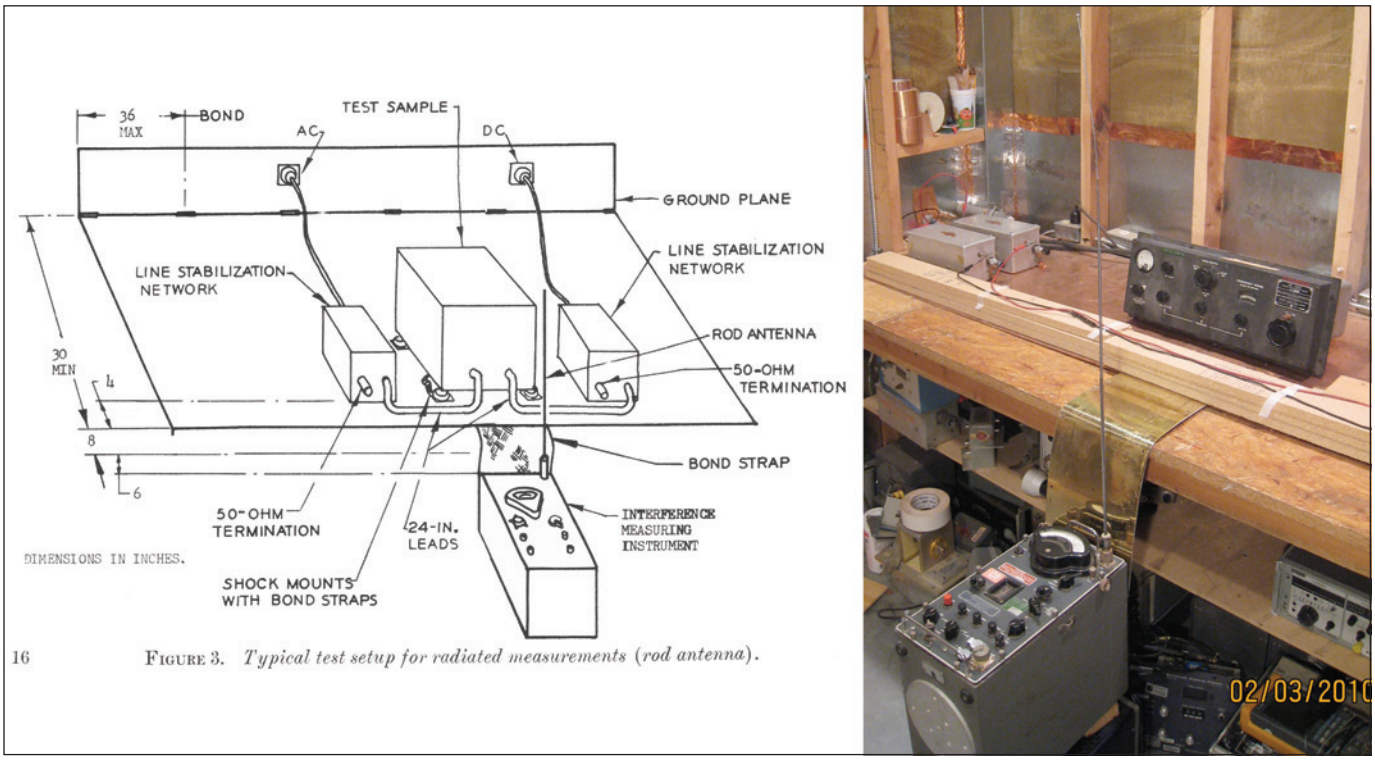


Figure 6: MIL-I-6181 rod antenna diagram and set-up recreation. As noted in the text, this is so near field that it isn't even an attempt to measure a field intensity; instead the potential induced in the rod is measured and is a crosstalk control, or very close to one.

Although it would be desirable to require the measurement of both the electric and magnetic components of the interference field, it is felt at the present time that such requirements would make specification testing excessively complex. Experience has indicated that aircraft electronic equipments, which operate in the lower frequency ranges (0.15 to 20 mc), are more sensitive to the electric field because of the unshielded high impedance antenna lead-in, which has been in general use. Present practice is to control the electric field by radio interference measurements. This is done by utilizing a 41-inch rod antenna and treating any difficulties arising from equipments generating strong magnetic fields as special cases which require particular attention when the equipment is installed in the plane. Reference (e) requires that all equipment used with antennas be designed for use with a shielded antenna lead. If and when the unshielded antenna lead is completely eliminated from use in aircraft, a review of present methods and limits in the frequency range 0.15 to 20 mc will be required. Radio interference meters using the 41-inch rod antenna are so constructed and calibrated that they read directly the microvolts which are induced in the antenna by the interference field."

Note: The reference (e) cited is MIL-I-6181B.

The above excerpt is remarkably lucid and showcases how well understood the problem and the solution were. The reader can demonstrate the electric field nature of the rod. Set up a wire above ground per MIL-STD-461E/F, driven at one end by a 50 Ohm signal generator. Load the other end of the wire with 50 Ohms, and place a 100 kHz, 100 dBuV amplitude signal on the wire. Record the measured field intensity (~1 mV/m, 60 dBuV/m). Now remove the 50 Ohm load from the far end of the wire. The wire potential will increase 6 dB due to being unloaded, so decrease the signal generator setting by 6 dB to keep the wire potential constant. The rod antenna measurement will indicate precisely the same field intensity reading as previously - despite that around 80 dB less current flows in the second configuration! A clearer demonstration of electric field sensing and magnetic field rejection cannot be had.

With that background as to how the 104 cm rod antenna came to be used for EMI testing, we progress to its implementation in the EMI test chamber. Figure 6 is a diagram and recreation of a rod antenna set-up from MIL-I-6181.

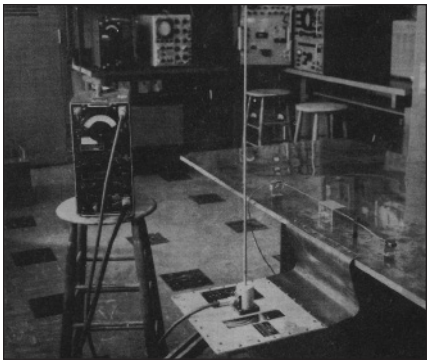


Figure 7: Picture of MIL-I-6181 RE test using a rod antenna prior to 1963. Now the engineer could be removed from the set-up. The connecting cable was shielded twin-axial transmission line, so if desired it could be run through a bulkhead feedthrough grounding the shield without introducing a ground loop into the instrumentation!

In Figure 6, the rod connects directly to the EMI meter. As bands were selected, the antenna was internally properly matched to the mixer input. The mixer tube presented a high input impedance, so that the 104 cm rod was not loaded as it would be by a modern mixer with an input impedance more nearly approximating fifty Ohms.

Note also the very short bond strap between EMI meter and ground plane. The rod antenna was only 12" from the test sample front face. That reflected achievable wire separation in that era's aircraft. The purpose of the bond strap was to make the ground plane the reference for the rod antenna's pickup potential. The EMI meter was battery-powered in this application; the ground plane is the sole ground reference.

As time went by, complaints arose about the difficulty of using the AN/PRM-1 meter in immediate proximity to the test sample. While a remote meter was provided with the AN/PRM-1, the controls still had to be adjusted on the meter face itself. Stoddart Aircraft Radio Company then provided a more modern version of the rod antenna, with its own base, passively tuned. This allowed remote use of the EMI meter itself. Figure 7 shows a set-up using the rod antenna with its own base in a picture of an EMI test from the 1950s or early '60s.

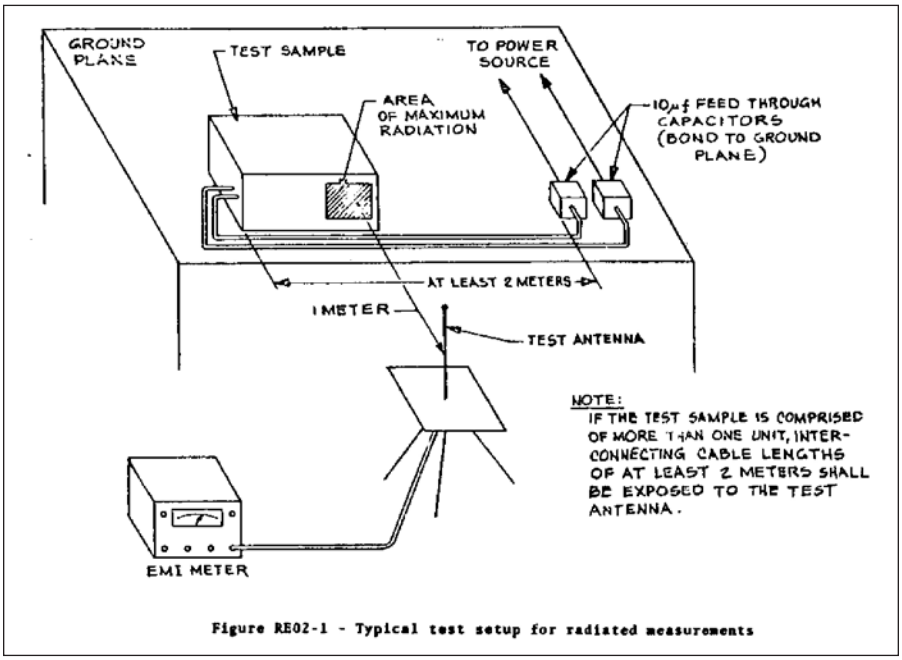


Figure 8: Rod antenna use per MIL-STD-462 basic release (1967). Many of the approved EMI meters at this time could be run on battery power, so that this set-up did not inherently ground the isolated counterpoise.

MIL-I-6181B specified the rod antenna only to 20 MHz, with dipoles used at higher frequencies. Later revisions pushed the breakpoint to 25 MHz (viz. 25 or 30 MHz for MIL-STD-461/-462, all versions).

TRI-SERVICE STANDARDIZATION

The Army, Navy and Air Force had their own Service-unique standards up to 1967. The purpose of MIL-STD-461/-462 was to provide a single Tri-Service standard, with attendant economies of scale.

MIL-STD-462 placed the rod antenna at a one-meter distance from the test sample, and floated the counterpoise from the ground plane (Figure 8). This was per the NADC-EL-5515 observation (quoted earlier) that as the open-wire lead-in radios were phased out of use and replaced by 50 Ohm coaxial input radios, the test method using the rod antenna at 12" would have to be revisited. The use of modern coaxial-shielded lead-ins moved the sensitive high impedance unshielded victim to the aircraft exterior where the antenna was mounted. Increasing the antenna-test sample separation was a response to the new radio-to-antenna connection technique. The counterpoise was only grounded through its coaxial connection to the EMI receiver, which was very important because at 14 kHz, the bottom of the RE02 band, a single point ground was necessary for measurement integrity when using a passive (octave-band tuned) rod antenna.

Another change related to the removal of the sensitive victim wiring from within the aircraft was the consequent attention placed on protecting the antenna from rfi. This resulted in a change from the antenna-induced limit to a modern field intensity limit.

A grey cloud appeared with the silver lining of removing the highly

FCC • Wireless • Telecom • CE Marking • International Approvals • Product Safety

Test Locally, Sell Globally and Launch Your Products Around the World!

From wireless routers to innovative applications in medical equipment, mobile technology's impact on the world is limitless. At CW we're not just researching what's new in wireless test standards, we're prepared for what's next in wireless technology.

Our extensive wireless capabilities include: DECT - DFS - Cellular/PCS/LTE/AWS/4G - 802.11 b/g/a/n WiFi Access Points - 802.15.4 Zigbee - 802.15 Bluetooth - VoIP - UWB (Ultra WideBand) - Automotive & Ground Penetrating Radar

We want you to experience the difference between customer service and total customer satisfaction!

357 Main Street – Sandown, NH 03873
(603) 887- 3903
www.ComplianceWorldwide.com
sales@cw-inc.com

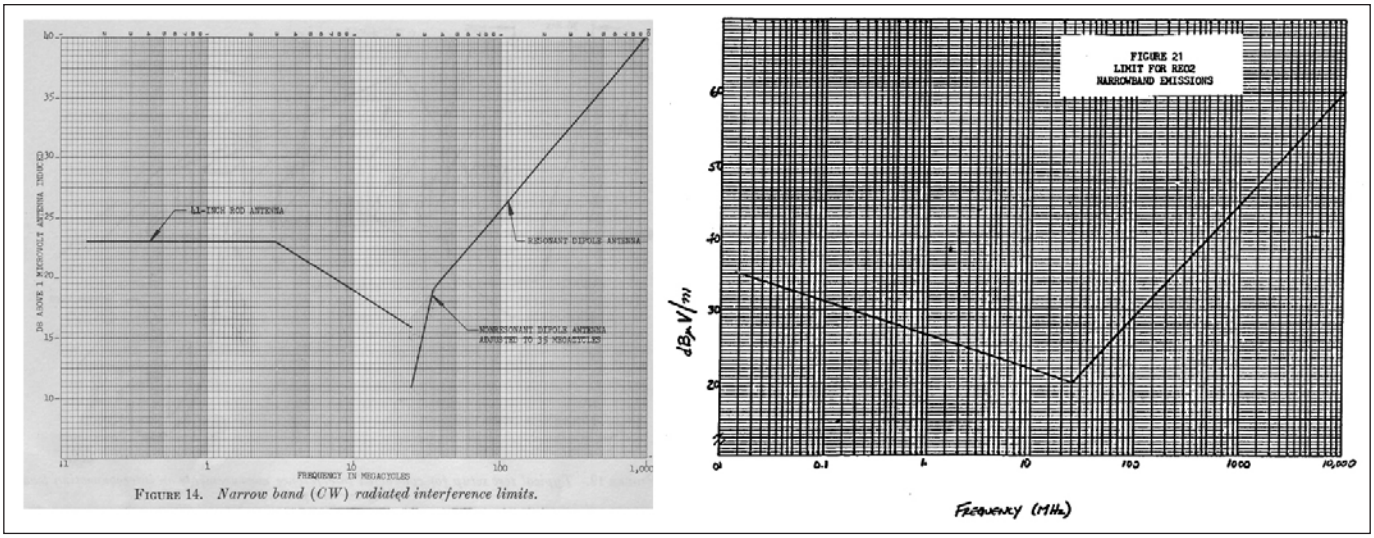


FIGURE 14. *Narrow band (CW) radiated interference limits.*

Figures 9a & b: MIL-I-6181 antenna-induced emission limit at left, showing discontinuity between vertical rod and horizontal dipole rf output at 25 MHz vs. superseding MIL-STD-461 RE02 limit (1967). Note how corresponding portions of both limits have similar slopes, reflecting the effective heights of the vertical rod and tunable dipole. One other change that should have occurred in 1967, but didn't until 1993 (MIL-STD-461D) is that with the external antenna as the focus of radiated emission control, there should have been separate limits for equipment installations depending on whether they were in or outside of a metallic vehicle.

sensitive unshielded wire from within the vehicle. The easily modeled and universal internal interaction devolved into a vehicle specific geometry where mostly internally generated fields had to find their way out of the metal vehicle to interact with an external antenna. Now failing to meet the RE102 limit is not a cause for immediate rejection, but something that needs to be evaluated by installing the device on the applicable vehicle and checking compatibility. This is recognized in MIL-STD-464 paragraph 5.2.4, which requires quantitative measurement of rfi coupled to vehicle antennas from vehicle electronics. Such measurements have been made even before MIL-STD-464 basic was released in 1997, but MIL-STD-464C made it a hard requirement in 2010.

MIL-STD-462 also replaced tunable dipoles with the 1.37 m tip-to-tip biconical antenna above the rod band. Whereas MIL-I-6181 and similar specifications required a dipole tuned as low as 28 or 35 MHz (on the order of 5 meters end-to-end), the shorter biconical can be tilted to be used vertically as well as horizontally. Pre-MIL-STD-461 EMI standards only required control of horizontally polarized coupling or fields, above 20-30 MHz, but MIL-STD-461/-462 controlled both polarizations above 30 MHz (log-spiral antennas were used above the biconical band, which captured both horizontal and vertically polarized fields simultaneously).

And finally, it was about this time that active rod antennas became commonly available. This was a technology development, not a specification or standard requirement. Instead of tuning a rod antenna through octave bands that tracked those of the remote receiver, the rod antenna drove a FET gate that acted as a near open-circuit load. This means that the 104 cm rod antenna's inherent open-circuit effective height of 0.5 meters (or 6 dB/m antenna factor) was achievable. Compared to tuning out the rod's 10 pF source impedance with one inductor per octave, the improvement in antenna factor was on the order of 50 dB at 10 kHz. This development facilitated the use of spectrum analyzers for EMI testing when they became available. The analyzer's sensitivity wasn't as good as that of the EMI receiver, but it didn't need to be, using an active rod antenna. The downside was that the active circuitry placed a limit on dynamic range for high-level signals, both for the rod and spectrum analyzer electronics. Response to a broadband signal could be quite limited, and if there was a strong out-of-band signal, that could diminish the ability to receive a low-level signal. The latter issue wasn't as important inside a shielded test chamber.

A PROBLEM CREEPS IN

In 1970 and 1971, Notices 2 (Air Force) & 3 (Army) were released. One area of commonality between Notices 2 and 3 was a change to the rod antenna configuration: whereas previously the counterpoise was floated from the ground plane, now it was bonded to it. This change found its way unimpeded into MIL-STD-462D (1993) and the consolidated MIL-STD-461E (consisting of both requirements and procedures) (1999). Notice 2 wording is as follows: "4. Paragraph 4.2.3.2 Add this sentence: When a counterpoise is used with a rod antenna, it shall be bonded to the ground plane with a strap at least 30 cm wide." Note that the 1967 set-up is similar to that of

the 2007 MIL-STD-461F RE102 rod antenna with the exception of the lack of the lossy ferrite bead increasing the impedance of the bond path. The 1970/1971 changes were a mistake, but it took three decades to realize it.

Recall that before MIL-STD-462, there was a change in antenna type and polarization at somewhere between 20-30 MHz, depending upon the particular specification and vintage. The efficiency of the vertical rod and horizontal dipole at 30 MHz was quite different, so that the Figure 9a antenna-induced limit on rf potential was discontinuous at the breakpoint, and the signatures were as well. But with MIL-STD-461 going to a field intensity limit, and MIL-STD-462 requiring both horizontal and vertical polarization of the biconical antenna, it is reasonable to expect some degree of continuity at the antenna change breakpoint for vertical biconical polarization. In fact, the RE02 and RE102 limits of all versions of MIL-STD-461 are continuous at the breakpoint (Figure 9b). The slope may be changing, but the limit amplitude is continuous. But after Notices 2 and 3 were released, it was not always the case that the signatures were continuous at the antenna breakpoints even for vertical biconical polarization. This is even more obvious if an overlap of data is taken between 20-30 MHz, where both antennas are calibrated for operation. Another and related issue that comes to light is that a surprising number of totally different test items all seem to have a broad peak between 20-30 MHz.

PROBLEM RECOGNITION

Messrs. Steve Jensen and Luke Turnbull separately identified shortcomings of rod antenna measurements in the last octave of use in 2000, and 2007, respectively. These were critiques against MIL-STD-461E RE102, below 30 MHz and similar automotive test standards. The issue was a great discrepancy between measured fields at the 30 MHz breakpoint between the rod antenna and the biconical antenna, vertically polarized. While one would not expect precise agreement, due to significantly different physical apertures, the 20 dB difference in the data below is problematic. Mr. Jensen showed by overlapping the biconical antenna and rod antenna from 20-30 MHz that the biconical always returned much lower levels.

Mr. Jensen flagged this issue in a critique of the draft MIL-STD-461F dated 23 March 2007. Air Force EMI personnel separately along with others had also noted enhanced levels of any noise present in the 20 to 30 MHz

Various configurations with different size counterpoises and grounding/bonding techniques were explored at Wright Patterson AFB.

frequency band. In conjunction with the Tri-Service Working Group (TSWG), the Wright-Patterson Air Force Base (WPAFB) EMI laboratory undertook a detailed study of the rod antenna setup. John Zentner and Steve Coffman with participation by the author performed the work. John Zentner had been deeply involved in the development of the "D" revisions of MIL-STD-461/462 and was the chairperson of the MIL-STD-461E TSWG. Steve Coffman was the Air Force EMC engineer for special operations aircraft with 30 years of experience in the EMC field. The result of the effort became the basis of the setup changes for the rod antenna introduced in the final version of MIL-STD-461F.

PROBLEM RESOLUTION

Various configurations with different size counterpoises and grounding/bonding techniques were explored at Wright Patterson AFB. It was found that a resonance condition with the MIL-STD-461E/462 configuration caused the potential of the counterpoise to rise to a level that swamped the potential induced in the rod antenna itself. Measurements from various configurations were compared. The configuration that produced the best results was a traditional size counterpoise that was not bonded to the bench top ground plane, closer to the floor than the tabletop ground plane, and with a short coaxial cable electrically grounded to the shielded room floor. Due to a remaining resonance between the counterpoise capacitance to the floor and the coaxial cable inductance, a lossy ferrite sleeve was applied to the coaxial cable to dampen the resonance. The required impedance of the ferrite sleeve was defined in the main body of MIL-STD-461F and a statement was included in the Appendix of the standard that a ferrite sleeve "lossy with minimum inductance" should be used. The results of the study were presented in public forums at the 2007 IEEE EMC Symposium and at the 2008 Department of Defense (DoD) Electromagnetic Environmental Effects (E3) Program Review.

The pre-461F parallel LC trap formed by the counterpoise over the floor and the coax cable connected at one end to the rod antenna base and at the other to the chamber wall caused the impedance between counterpoise and chamber to increase greatly; hence the same

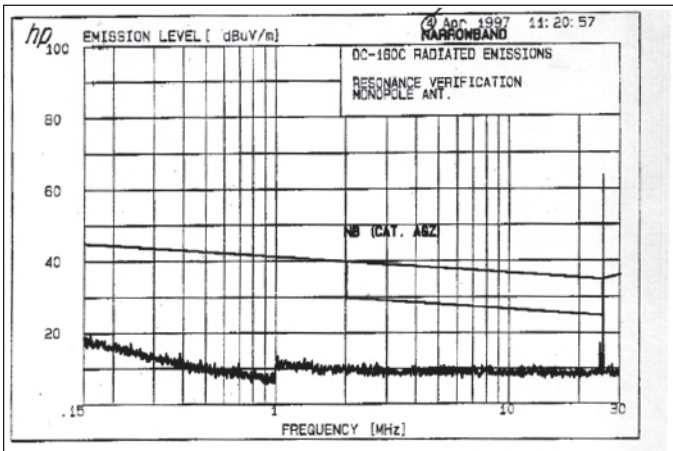


Figure 4 – Emissions from a vertical wire using Rod antenna at 25 MHz

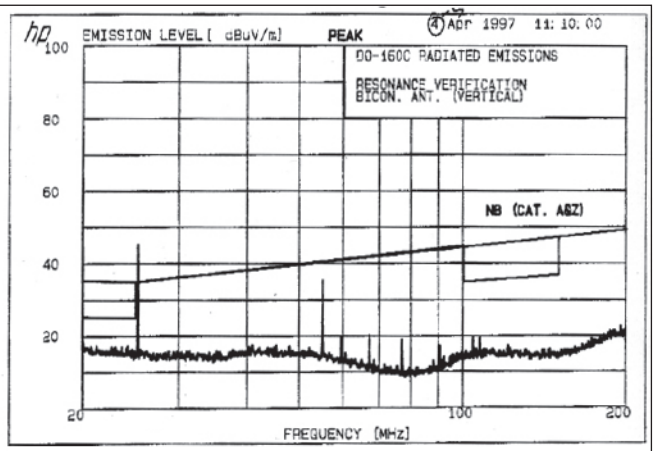


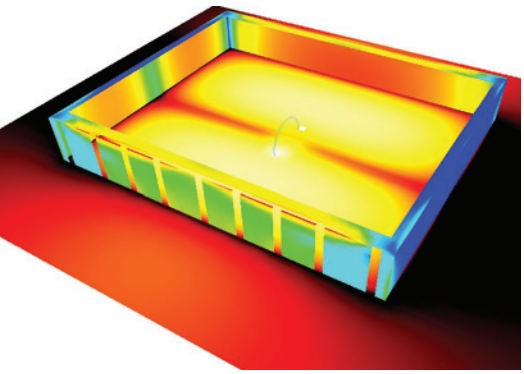
Figure 5 Emissions from same source as Figure 4 using vertical bicon.

Figure 10: Data from Jensen, Steve. "Measurement Anomalies Associated with the 41 Inch Rod antenna when used in Shielded Enclosures," dated 17 July 2000. Once you know to look for this, you will see it over and over again – unless you are working to MIL-STD-461F or later.

While modern versions of RTCA/DO-160 no longer use the rod antenna, DO-160C rod use was no different than that in MIL-STD-462. Modern DO-160 replaces RE measurements with a common mode current control below 100 MHz. Recall the rod antenna's electric field response and magnetic field rejection. Does DO-160F/G really control electric fields below 30 MHz from a high impedance cable?

Make the Connection

Find the simple way through complex EM systems with CST STUDIO SUITE



Emissions from a server housing

Components don't exist in electromagnetic isolation. They influence their neighbors' performance. They are affected by the enclosure or structure around them. They are susceptible to outside influences. With System Assembly and Modeling, CST STUDIO SUITE helps optimize component and system performance.

Involved in emc/emi analysis? You can read about how CST technology is used for EMC/EMI analysis at www.cst.com/emc.

If you're more interested in microwave components or signal integrity analysis, we've a wide range of worked application examples live on our website at www.cst.com/apps.

Get the big picture of what's really going on. Ensure your product and components perform in the toughest of environments.

Choose CST STUDIO SUITE – Complete Technology for 3D EM.

CST

field that coupled to the 104 cm rod was able to increase the potential of the counterpoise as well. The impedance between counterpoise and chamber in the absence of any detuning at WPAFB is shown in Figure 11.

Javor 2011 showed the result of detuning this resonance (Figure 12). That effort used a one-meter long wire suspended 5 cm above ground driven and loaded by 50 Ohms as the electric field source. The voltage on this wire was constant vs. frequency, and the article provides the quasi-static physics and math to demonstrate that the resultant electric field as measured by the rod antenna should also be flat vs. frequency, so that any departure from flatness is a measurement error.

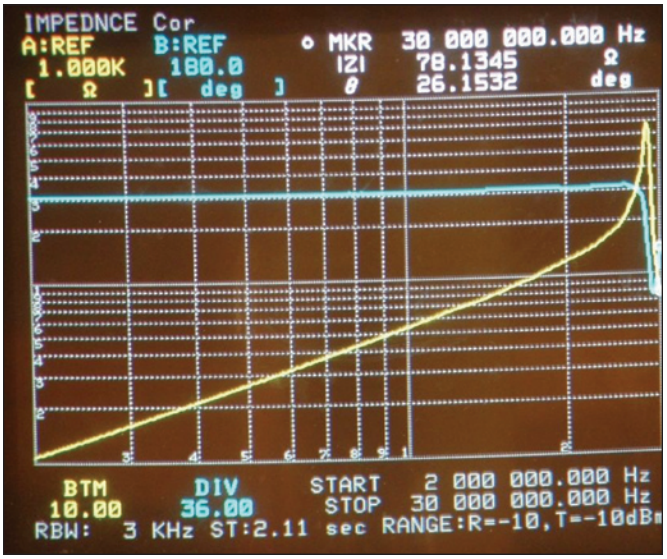


Figure 11: Classical parallel L - C trap impedance (yellow is amplitude, blue is phase). Every so often theory and practice coincide so perfectly that the term "textbook" just begs to be used.

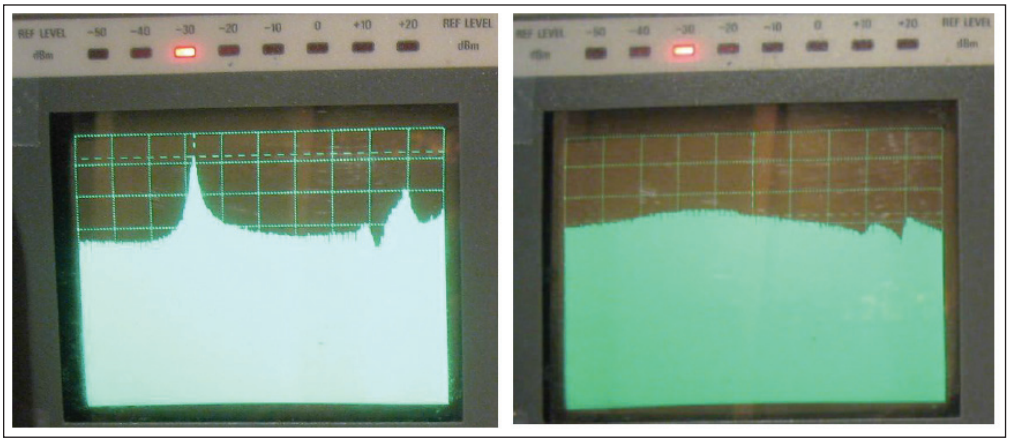


Figure 12: Pre-MIL-STD-461F resonance on left; MIL-STD-461F lower-Q resonance on the right (both plots have same reference level, are 10 dB/division and cover 2 – 32 MHz). Measurement technique fully described in Javor 2011. The low frequency peak on the left is due to an extremely long coaxial cable being used – a variety of lengths were tried to see the effect before your author figured out what was happening.

LOOKING AHEAD

It is clear that the MIL-STD-461F technique went a long way towards eliminating a large error source. It is also clear that it is not perfect. Javor 2011 showed the result of completely floating the counterpoise (eliminating, not detuning, the resonance), and that gave a nearly flat result, and more importantly, almost exactly the same result as when both test sample and rod antenna are both referenced to the chamber floor as in Figure 13. A US$50 Mini-Circuits isolation transformer was used in lieu of the ferrite sleeve.

Figure 14 (page #) shows measurement results when the source and the rod antenna are both referenced to the shield room floor as in Figure 13. The flatness of the measurement is very close to perfection. Figure 15 compares the -461F result (top trace) to using an isolation transformer (lower trace) in lieu of a ferrite sleeve in the -461F set-up. The Figure 15 (page #) isolation transformer lower trace response is very close to that of the Figure 14 floor-based measurement.

It should be clear that the isolation technique of eliminating the resonance is potentially superior to the detuning technique, but a few hurdles remain. These include transmission line transformer vs. a true isolation transformer, and the efficiency (loss) associated with the transformer. With a 24 dBuV/m limit above 2 MHz, not much loss is acceptable. Members of the MIL-STD-461 Tri-Service Working Group have been working this problem since 2011. There is a separate practical motivation for using isolation instead of detuning. The -461F technique requires grounding the coax shield directly below the rod antenna. Many test facilities don't have a readily accessible floor grounding point available everywhere, due to various coverings that are sometimes used over the metal floor, such as tile or concrete. An isolation technique eliminates the need for grounding. That advantage has many people interested in this approach entirely separate from a desire for better test data.

A CONCERN WITH MISINFORMATION

Unaware of the body of work resulting in MIL-STD-461F and the continuing work by the TSWG based on Javor 2011, Mr. Harry Gaul of General Dynamics published and presented an article on the same subject in/at the 2013 EMC Symposium in

Denver.[1] Gaul 2013 comes to the same conclusion as Javor 2011; namely that counterpoise isolation is superior to detuning a resonant circuit. The Gaul 2013 approach was entirely different than employed in Javor 2011, and it is reassuring that the two entirely different techniques ended up with the same conclusion. Mr. Gaul used a method of moments code called FEKO, whereas Javor 2011 performed a closed form analysis calculating the coupling from the electric field from a wire above a ground plane to a 104 cm rod antenna, based on first principles – quasi-static electric field formulation based on Gauss' Law. Both efforts compared the predictions with measured test data, but that is where the similarity ends.

Both Javor 2011 and Gaul 2013 evaluated several different antenna configurations between 20 – 30 MHz. These are complete isolation of the counterpoise, -461F, -461E, -462, and floor mounting of the rod antenna, as well as use of a vertical biconical.

Your author, a member of the Tri-Service Working Group on MIL-STD-461F, was aware of the precise damping ferrite described in the standard, and the test results in Figure 12 verify how well it works. MIL-STD-461 cannot identify any commercial product or service by trade name, and instead has to specify a device by its salient characteristics. Mr. Gaul unwittingly identified a (non-technical) flaw in MIL-STD-461F: part of the ferrite description is not in the main body of the standard, but in the appendix, which is not contractually obligatory. In the main body, the ferrite is identified as having an impedance of 20 – 30 Ohms at 20 MHz, and in the appendix the following statement is made: "Floating the counterpoise with the coaxial cable electrically bonded

1 Gaul, Harry. Electromagnetic Modeling and Measurements of the 104cm Rod and Biconical Antenna for Radiated Emissions Testing Below 30 MHz. 2013 IEEE EMC Symposium Record. Denver, CO.

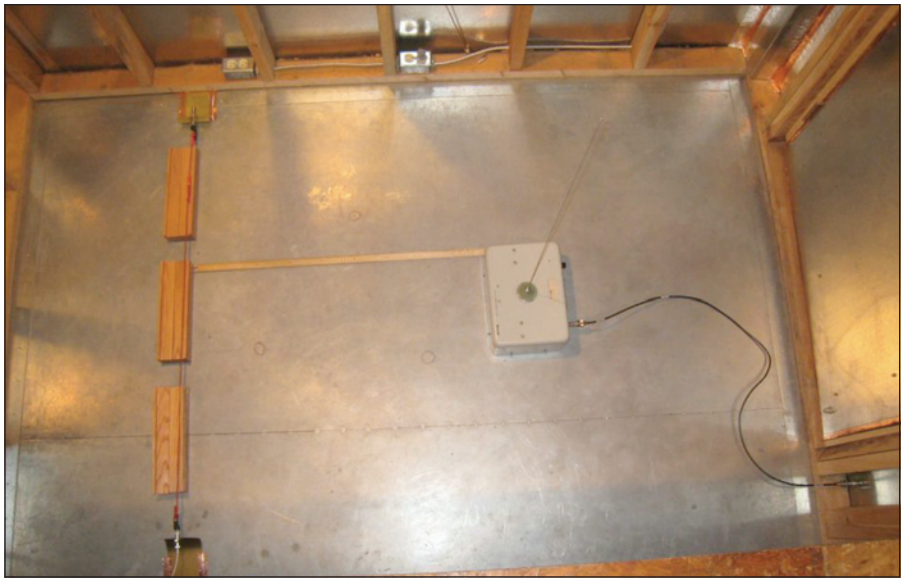


Figure 13: Both the radiating element (wire above ground on the left) and the measurement antenna are referenced to the shield room floor, ensuring a common potential for the measurement and the absence of any sort of resonant condition. Above ground rod antenna measurements such as MIL-STD-461, RTCA/DO-160 (obsolete versions), CISPR 25 et al. should all produce results commensurate with a common ground plane measurement. It is the gold standard.

at the floor with a weak ferrite sleeve (lossy with minimum inductance) on the cable produced the best overall results." One ferrite that meets this requirement is the Leadertech (used to be Ferrishield) CS28B1642 using 28 material. Its measured impedance (courtesy of Mr. John Zentner at WPAFB) is listed in Table 1.

Note that at 20 MHz the impedance is higher than the MIL-STD-461F requirement; the requirement was based on the manufacturer's data, not measured data. But the resistance (real Ohms) is higher than the inductive reactance (imaginary Ohms), as required, and this provides the necessary damping performance.

In contrast, Gaul 2013 uses the following analytical model for the ferrite sleeve, which provides no damping whatsoever:

> "The ferrite bead (when used for the MIL-STD-461F configuration) is modeled as a parallel circuit of 480 ohms, 0.255pF, and 250nH to match the characteristics of the actual bead used."

At 20 MHz, 250 nH provides about 30 Ohms inductive reactance, but as noted, the parallel 480 Ohms provides no damping at all. The effective impedance is still 30 Ohms inductive. Unfortunately, based on his misunderstanding of the MIL-STD-461F approach, Gaul 2013 states that:

> "The MIL-STD-461F test setup had the worst agreement with about 18dB difference."

That pejorative conclusion is unsurprising given an assumption of purely inductive bead impedance: it doesn't take a sophisticated computer program to determine that adding inductance to the inductive leg of an LC trap simply reduces the tank frequency, without reducing the circuit "Q."

Misunderstanding of the purpose of the ferrite sleeve is distressing. The TSWG thought it would be clear that the purpose of the sleeve is for damping, based on the overall wording in MIL-STD-461F. If damping is retained over isolation, future versions of MIL-STD-461 will certainly clarify this issue in detail.

CONCLUSION

In today's world, there is an expectation that technology improves over time. With respect to rod antenna measurements over the last threescore years, we might instead be inclined to quote Jerry Garcia and say, "What a long, strange trip it's been."

The radiated emission problem was well understood six decades ago, and they had both a test and design solution in hand. But when the design solution took hold, the test solution changed and became problematic. We have spent the last several decades in a sort of mini-Dark Ages, where we were not doing as good a job as when we began, and weren't even aware of it. But thanks to Steve Jensen, Luke Turnbull, and the DoD TSWG, we have turned the corner on a mini-Renaissance and now (in MIL-STD-461F) have a much better test, and for the last several years have been pursuing an even better approach for -461G (counterpoise isolation).

Aside from the 60th anniversary aspect, the motivation to write this article is due to multiple interactions with people reacting to the MIL-STD-461F change without adequate understanding of the background. One objection was that the -461F configuration lowers measured emissions from previous configurations. That is true

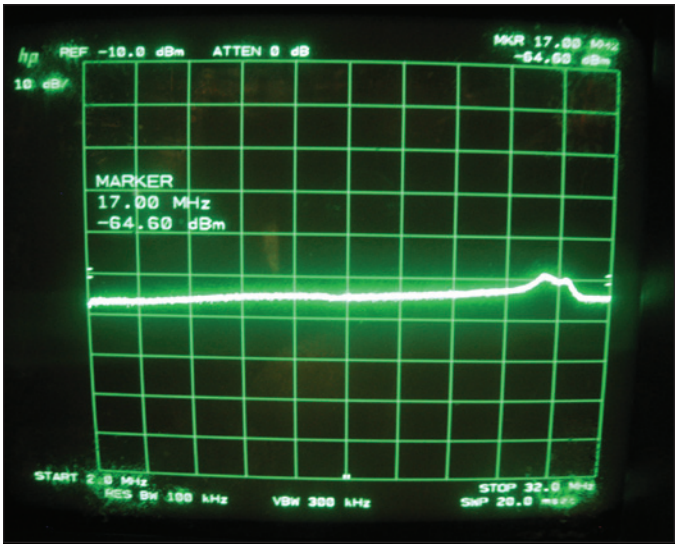


Figure 14: Field intensity measurement results when radiating wire and rod antenna are both referenced to test chamber floor per Figure 13

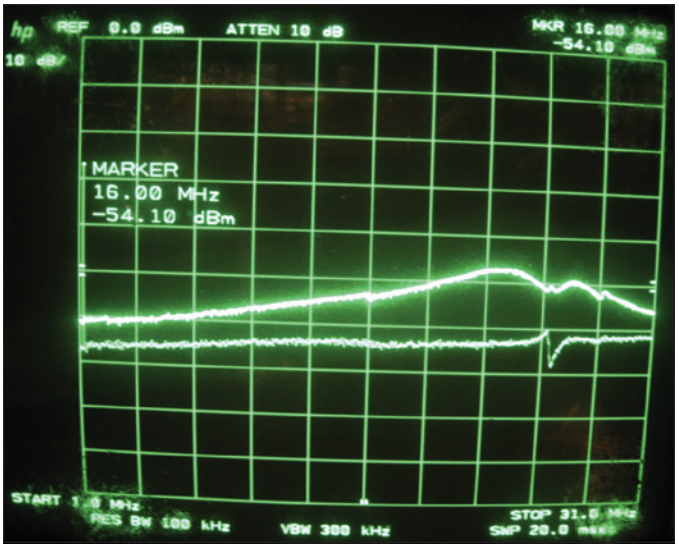


Figure 15: Upper trace is -461F result; lower trace is result using isolation transformer in otherwise -461F set-up

(especially in the resonance band) but that is also the point - more accurate measurements reveal that the true field is lower than previously measured. Careful measurements at WPAFB revealed that when the resonance is removed via -461F, a previously masked dropout is visible, but that is because of a destructive interference node due to room dimensions and inadequate absorber performance. The MIL-STD-461F Table I absorber requirement is a considered compromise between rf performance and economic impact. If the dropout is a concern, the solution is better absorber (hybrid based on a ferrite tile foundation), not maintaining a counterpoise resonance to offset a chamber-induced destructive interference. And of course the frequency coincidence of these two resonances only works for specific room dimensions, not in general. IN

The author wishes to thank the following EMC engineers for above-the-call-of-duty reviewing of this article. John Zentner and Steve Jensen, both mentioned and identified within the article, also took the time to review this effort. Mark Nave of Mark Nave Consultants, Inc., Vince Sutter of Raytheon, and Tim Travis of ASRI all contributed to making this article a more user-friendly reading experience. To the extent that it isn't, the fault lies entirely with the author.

REFERENCE

1. Ken Javor, "On the Nature and Use of the 1.04 m Electric Field Probe," *Interference Technology Engineering Master (ITEM)*, 2011.

Freq MHz	Real Ohms	Imag Ohms
10	23.663	31
11	25.942	32
12	28.144	33.5
13	30.317	34.5
14	32.459	35.5
15	34.563	36
16	36.674	37
17	38.710	37.5
18	40.693	38
19	42.603	38
20	44.464	38.5
21	46.268	39
22	48.021	39
23	49.765	39
24	51.444	39
25	53.050	39
26	54.595	39
27	56.107	39
28	57.588	39
29	59.039	39
30	60.440	38.5

Table 1: Leadertech CS28B1642 ferrite bead impedance. The highlighted row shows the critical parameter at the frequency specified by MIL-STD-461F: the resistive impedance is higher than the inductive reactance. Note that this model has the two impedance components in series, which is standard in the industry, not in parallel as in Gaul 2013.

(the author)

KEN JAVOR

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

Are You Ready for Entry to China?

BY PAUL WANG

China is becoming the largest consumer market in the world. Electronic equipment especially high-tech devices are most popular in China. An attractive market, yes, but are you prepared to enter this vast marketplace?

Like any country in the world, China has its own regulations for electronic equipment. China Compulsory Certification (CCC) is the most widespread certification you need to overcome.

CCC certification covers a wide range of products, electrical and non-electrical, which are listed in the CCC category. This category may be updated according to the government's regulatory requirements. For example, some medical equipment was recently removed from the CCC category.

WHAT ARE THE REQUIREMENTS OF CCC?

CCC certification contains three phases: type testing (safety and EMC), initial factory inspection and follow up inspection. Currently, there are mainly three certification bodies for electronic equipment: China Quality Certification Center (CQC) which is the biggest certification body and can issue all electronic equipment CCC applications; China Information Security Certification Center (ISCCC) can issue information technology equipment (ITE) CCC certificates; China Electronics Standardization Institute (CESI) can issue Audio Video CCC certificates.

TERMS YOU NEED TO UNDERSTAND

Manufacturer is the company who designs the product and owns the patent. Factory is where the end product is assembled, tested and labeled. If the manufacturer and the factory are different, then it will be original equipment manufacturer (OEM) or original design manufacturer (ODM) mode. Each CCC certificate can only list one manufacturer and one factory, so if you have more than one factory manufacturing your product, you must apply for a CCC certificate for each factory. For OEM mode, the manufacturer can add multiple factories without retesting but each new factory should be CCC approved or needs to be inspected if it is not CCC approved. For ODM mode, the factory can add multiple manufacturers without retesting. The CCC certificate is valid for five years but may also depend on the OEM/ODM agreement. If the agreement is less than five years, your CCC certificate may be valid for a shorter period of time. So to avoid such problem, it is important to sign a longer agreement.

CCC refers to Chinese national standards (Guobiao or GB standards). Usually the GB standard is harmonized to an IEC standard.

GENERAL PROCESS

The applicant (must be a company or organization) can submit the application to the certification bodies mentioned above. Once the application is accepted, the manufacturer must send samples to the accredited lab in China to test. There are many accredited test labs you can choose but each lab has its own category and region. For example, some test labs can only test products manufactured in Japan, some can only test products manufactured in North America. If there is no failure during the test, the test report will be issued by the test lab and reviewed by the certification body. This process does not always go smoothly. The test engineer may require some additional information like the full company names of the component manufacturers; special ratings of certain components like the thickness of the insulation tape of the transformer, the creepage distance of the optocoupler; updated power supply label with the altitude or non-tropical zone symbols, etc. After all the information is provided, the report will be approved and the CCC certificate will be released after the payment has cleared. Then, as long as the factory is CCC approved, the manufacturer can move forward by applying for the CCC mark approval with the CCC certificate.

STANDARDS

CCC refers to Chinese national standards (Guobiao or GB standards). Usually the GB standard is harmonized to an IEC standard. For example for ITE: GB4943 is harmonized to IEC60950; GB17625 is harmonized to IEC61000-3-2; GB9254 is harmonized to IEC/CISPR 22. There are some minor national deviations like ratings, altitude or tropical zone requirements. Generally, if you can pass the IEC standard, you should be confident in passing the CCC test.

WITH CB OR WITHOUT CB?

Use of a CB report may be a double edged sword. The benefit of transferring CB report to CCC report is obvious: save time and reduce cost. If the product is complex and the components are not CCC or CQC approved, using CB report to avoid component level test is a good choice. However it is important to confirm information used on CB report is accurate. For example, the company name, factory address, product model numbers, ratings and components must be the same as CCC report. If you want to add or change some components, you must update the CB report first which may add more time to the process. So in order to use CB more efficiently, it is important to double check all the related information for accuracy, and modify as needed to avoid delay.

FACTORY INSPECTION

CCC requires an initial factory inspection and a follow-up inspection. The purpose of this requirement is to assure product consistency. The requirements of the inspection include two aspects: quality control and product consistency. Quality control is similar to ISO9001 system. You need to have all the procedures and documents ready to control the product quality. Product consistency requires the product on the production line be exactly the same as the test sample, like the components, construction, company information, etc. The verification test report and routine test will also be checked. If the standard is updated, you need to update your CCC report before the deadline and provide the updated CCC certification to the auditor during follow up inspection.

HELPFUL TIPS

- CCC accepts model series so you can group similar products into one family to reduce cost.
- Pretest your samples before sending to the test lab to avoid failure.
- Provide required information in time to avoid delay.
- Conduct internal audit or mock audit to avoid factory inspection failure.

LATEST NEWS FOR GB17625.1 STANDARD UPDATE

The GB17625.1-2012 standard was released on July 1, 2013 to replace the GB17625.1-2003. This standard update will affect Information Technology Equipment, audio video products, electrical tools, lighting devices, telecom terminals, and part of household products. Manufacturers need to update the standard before the next factory inspection this year. Or they can conduct testing in an ILAC approved, self-owned lab. Products with input power less or equal to 75W, testing can be exempted. IN

(the author)

PAUL WANG
works for G&M Compliance Inc. in the China office as Technical Director, mainly focusing on China certifications. He is also on the Board of Directors of IEEE Product Safety Engineering Society. He can be reached at paulwang@gmcompliance.com.

ONE WORLD ○ OUR APPROVAL

ONE Nemko

Nemko is celebrating our 80th anniversary by launching a new strategy with expanded services as well as an enhanced logo as the symbolic image of our significant global presence.

One world – our approval

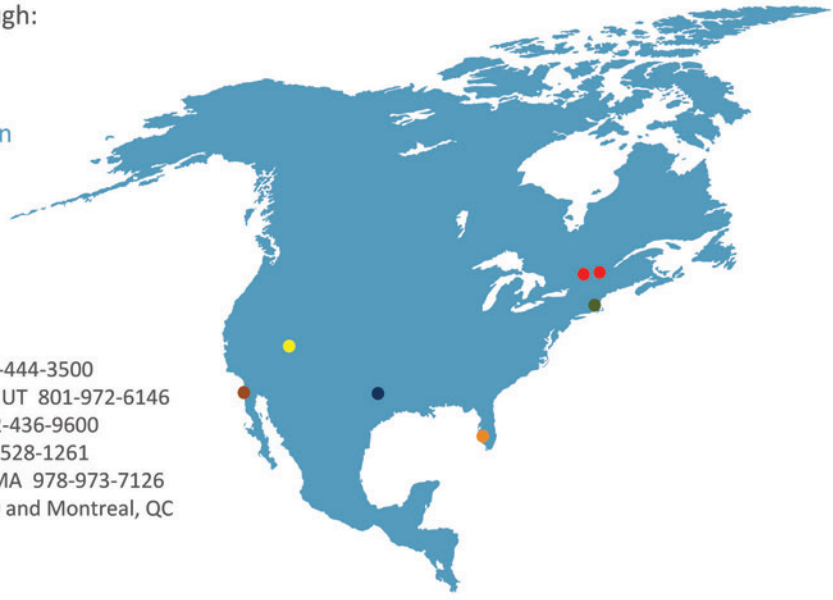
Companies around the world trust Nemko to assess their products, systems, installations and personnel for conformity with relevant standards and regulations.

Since 1933, we have ensured that our customers comply with requirements everywhere in the world. Our services include pre-compliance, product testing, international approvals, and product and system certifications.

Through our offices, laboratories and extensive partner network in Asia, North and South America, Europe, Middle East and Africa we are committed to being a strategic partner to serve our customers in a reliable, efficient and open manner.

We combine local presence with global knowledge and expertise, reducing your time to market through:

- Pre-compliance
- Product testing
- Product and system certification
- International approval



- West Coast Operations, San Diego, CA 760-444-3500
- North Mid West Operations, Salt Lake City, UT 801-972-6146
- South Mid West Operations, Dallas, TX 972-436-9600
- East Coast Representation, Tampa, FL 813-528-1261
- North East Coast Representation, Boston, MA 978-973-7126
- Nemko Canada, Ottawa, ON 613-737-9680 and Montreal, QC

nemko.com


Notebook PC
tablet PC
Smart Phone

Filter Connectors from a 2013 Perspective

BY FRED KOZLOF

Filter connectors are often a misunderstood product for many components engineers.

The lack of understanding is often a result of the fact that filter connectors seldom make the "What's New" headlines and because many engineers typically don't have a need for them. But those who do are certainly glad they are available!

Filter connectors are an invaluable tool in the world of electromagnetic compatibility (EMC). As such, designers and engineers primarily responsible for EMC will most often encounter the need for this possible solution to their problems.

Back in 1983, when the FCC Part 15 rules came out, and many electronics manufacturers (especially the computer folks) scrambled to figure out how to make their products compliant or risk it not going to market, the problem was most often referred to as EMI because interference was the big issue. Now the broader term EMC is used and applies to nearly every product in nearly every industry. So depending on who you work for, in addition to FCC Part 15 you will encounter EMC requirements based on MIL-STD-461, CISPR, FAA (AC20-136), and others from NASA, Boeing, Airbus, medical device or automobile manufacturers - and that's just the North American standards. Seek out the European equivalents and you will have a pile of CE directives hidden in all those IEC specifications.

Designers must ensure that their product does not interfere with other electronics while also tolerating some specified level of exterior RF (thus the concepts of interference and susceptibility were rolled into one, and called compatibility). Controlling EMC boils down to three methods: shielding, filtering, and most important…. minimizing the energy and frequency spectrum that needs to be contained.

The proliferation of personal electronic devices (tablets, smart phones, e-readers, GPS, etc), has been a two sided coin. These compact handheld devices are seldom connected to another piece of equipment due to their wireless capability - reducing input/output connectors and resulting in a multitude of EMC challenges. But the abundance of such RF emitting devices around equipment that is interconnected necessitates rigorous attention to EMC. You can quickly get an appreciation for this, when you consider medical electronics in hospitals, test or process control instruments in a factory, and the ever changing rules aboard aircraft. Then there's all those new electronic devices carried or even worn by military personnel or emergency response workers.

Over the years an extensive science has evolved helping circuit designers minimize the need for filtering and shielding through careful design and layout of components in their circuits. But ultimately, all final designs will utilize all three methods.

This article focuses on the filtering method. Filtering simply means the control of the frequencies, the energy that they contain, and limiting where they go. Components that are frequency sensitive are capacitors and inductors. Filter connectors integrate capacitors, inductors, or both, inside a connector. Most often the connectors of interest are the input/output connectors, since those are not only the transition from the device to the outside world, but they are also the 'antennae' for concerning frequencies both coming and going.

As a result, the most popular and most filtered types of connectors are D-subminiature and their related families (which actually originated in MIL-C-24308), several circular types like MIL-DTL-38999, MIL-DTL-83723, and aviation industry specific ones like the ARINC 404 and 600 connectors. Typically, such use is for professional equipment, not consumer products.

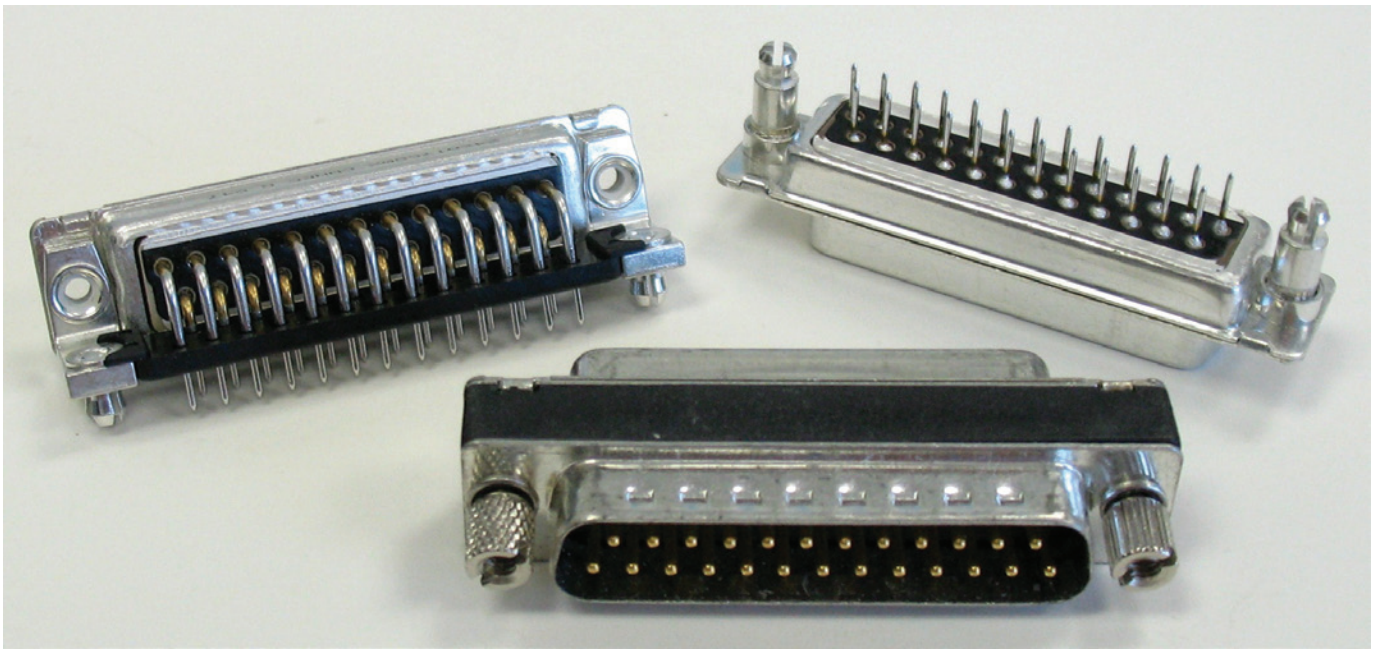
The capacitor is the primary filter component, typically of a special construction that lends itself to fitting into the tight confines of a multi-pin connector. One lead is connected to a contact the other to ground. The ground ultimately is connected to the shell and the device enclosure. While some filter connectors use simple 'chip caps' mounted on a substrate configured for the contact layout, the higher performance filter connectors use either tubular ceramic capacitors, or ceramic planar arrays. The very high end filter connectors contain multiple capacitors and ferrites to create a Pi type of filter.

Filter performance can range from a few dB (ferrites, chip caps) of attenuation, to 80 or more dB when used in Pi or higher order filtering, in a properly shielded and grounded connector design.

The key to a successful design is to only pay for what you need. Understanding your needs, the methods available to meet the specification and effective implementation will provide a marketable product.

So what makes the use of filter connectors desirable? If you have to use just one word – performance – they work. Key reasons why they offer advantages:

1. Filter performance far exceeds comparable filters placed elsewhere in the circuit. There's a lengthy engineering explanation of why, but a 60 dB filter inside a connector, might only provide 15 to 30 dB if placed somewhere on the PCB behind the connector. While not all designs need 60 dB, some modern electronics do, leaving a filtered connector as the only EMC choice.
2. Higher frequency effectiveness, while related to #1, occurs due to more compact packaging, better shielding around the filters, and especially because of lower impedance ground connections. The rapid expansion of 'wireless' devices has made the need for high frequency control much more important than it was even 10 years ago. Useful filtering above 1GHz. is common, and necessary.
3. Space. The drive for compact designs might welcome component removal from the PCB and hide them inside the connector.
4. Component reduction. A 25 position D-sub, when filtered might remove 25 or more components from the PCB, when replacing an 'on-board' filter design.



5. Flexibility of EMC design and performance. A filter connector can easily be changed for one of different filter properties. Some filter connectors are 'add-on' adapters, which can be used on location specific installations.

It has been said that the use of filter connectors indicates that other aspects of the EMC design process have failed. Theoretically that might be true, however not all designs and not all markets have the ability to fully utilize only the alternatives. There are many high-performance, highly critical applications that do not have the development time and cannot risk avoiding the cost of a filter connector. Price has typically been a perceived downfall of filter connectors.

Filter connectors have a broad range of performance and prices. Higher volume, commercial filtered D-subs, start in the $3.50 and up range. Deliveries can range from stock, to 6 weeks. At the other end of the spectrum, aviation types, like ARINC 600 can be $1000 or more and take 18 weeks. The shock factor of such price and delivery will depend on what industry you work in, and your cost alternatives to meet EMC.

There will always be a market for the effective use of filter connectors as designers match their needs and apply cost effective solutions that work. Many $1,000 electronic boxes and $1,000,000 electronic systems would not meet EMC needs without the use of filter connectors.

Filter connectors continue to meet a specialized need in electronics design. Because each EMC situation is unique, it is important that designers work with filter connector suppliers to optimize their selection. Suppliers who make filter connectors a focus product will generally be most capable of providing superior technical support in the early consultation stage and will work to provide the designer the right product, at the right price, to meet his need. IN

(the author)

FRED KOZLOF
is currently with CONEC. Fred was involved with commercial filter connector design back when the FCC regulations were implemented!

The Value of Certification

BY CARL NEWBERG, FOR THE EOS/ESD ASSOCIATION, INC.

What does "certification" mean to you?
What is the value of becoming "certified?"

The answer to this question has to include an answer to another question, "what is being certified?" In the electrostatic control arena, the world's premier organization for education and standards development is the EOS/ESD Association, Inc. The ESD Association (ESDA) has established several types of certification. The ESDA offers facility certification programs to ANSI/ESD S20.20 through the various certification bodies that also perform audits and certification reviews to ISO 9001. They also offer personal certification programs, namely the Program Manager, Device Design, and Device Stress Testing Certifications. These prestigious titles carry a wealth of meaning behind them in terms of knowledge, competence, and problem-solving ability. In addition to the certifications offered by the ESD Association, the ESDA is also affiliated with the International Association for Radio, Telecommunications and Electromagnetics (iNARTE), a brand of RABQSA International, which offers certification for ESD Engineers and Technicians. The ESDA, through this affiliation with RABQSA, provides a substantial amount of training for person's seeking iNARTE certification.

What is the benefit of being certified as either an ESD Program Manager, iNARTE ESD Engineer/Technician, or a Device Design professional? Certification provides confirmation that a person meets certain criteria of knowledge and problem-solving ability. Certification can be beneficial on multiple levels.

For the certifying organization, it provides standard practices that create discipline within the industry, it provides awareness and advances in technology, and it can provide increased cooperation between organizations.

For the employer, it can result in increased safety, higher product yield, and increased customer and employee confidence that produces dedication and improved teamwork.

For the certified professional, it provides credibility in the industry; it demonstrates knowledge, experience and competency. It typically creates increased opportunities for career advancement and increased earnings. It is clearly one form of professional development, and can improve job performance through the increased confidence that comes with "knowing what you know."

Becoming certified often requires extensive training and testing. This could mean, as in the case of facility certification, the facility follows processes that meet the requirements of industry standards. Companies who become certified are looking to ensure a higher quality of product and higher product yield. There is also a matter of safety, so, for employees this can mean significant improvements in job performance. Not only does certification have relevance to the individual company, but also to its vendors and suppliers. The Independent Distributors of Electronics Association (IDEA) has required that members be certified to ANSI/ESD S20.20 by an ESDA recognized certification body.

In the case of individuals, certification verifies a level of technical skill that will differentiate them from those not certified. By taking the time to learn the material, and retaining that knowledge to pass the certification exam, individuals will show a dedication to the industry, obtain significant contacts through networking, and show a technical prowess, which will increase their job performance. Many companies view certification as a requirement when hiring. With the competitive nature of companies looking to hire, it is almost certain that being certified will give one an advantage over the competition vying for limited jobs in the industry. As one recent Certified Program Manager stated, "The ESDA training seemed the fastest way to bring me up to speed... Going through all of the tutorials and taking the exam allowed me to meet a network of sources that I have been able to discuss ESD related issues with and resolve problems."

When comparing certification programs there can be significant differences, and on an individual basis, one may provide a better fit to your job and/or interests. Brian Lawrence of iNARTE made the following comparison of the ESD Associations professional certification programs and iNARTE Certification. "From my perspective the major differences between the certification offered by our two organizations are that the ESD Association certificates are focused on the two career path skill sets required for Program Management and Device Design. The iNARTE certification covers these same skill sets but less intently..." Professional Certification is appropriate for engineers and technicians whose training and experience have primarily focused on problems, engineering design and corrective measures associated with minimizing or eliminating electrostatic discharge. The ESD Association has a renewed agreement with RABSQA to assist with the iNARTE certification programs. The ESD Association tutorials are the main training materials for the iNARTE ESD Technician and ESD Engineer certifications offered by RABSQA.

As semiconductor technology progresses to smaller features, the susceptibility to ESD increases. Engineers with state-of-the-art knowledge are required to develop improved protection designs and factory controls to maintain production yields at the highest levels. The principle goal behind the ESD Association's Professional Certification programs is to ensure the understanding of the standard practices and problem solving techniques used to create ESD protection structures and controls in the workplace. In many areas of the industry, current knowledge of ESD Controls is not adequate, and process capabilities of ESD controls are often misunderstood. Device design and factory personnel must prepare to handle the increased ESD sensitivity levels. Having a more comprehensive understanding of ESD control techniques will be required in the factory. Possessing the knowledge to make all of the required measurements is an essential skill for maintaining an Electrostatic Protected Area. These factors are all more likely to succeed with the ESDA certification programs.

ESDA PROGRAM MANAGER CERTIFICATION

The ESDA Program Manager Certification was developed for individuals that are involved in designing, implementing, managing and auditing ESD control programs in their facility. The program was designed to meet the requirements of the ANSI/ESD S20.20 standard. The certification for Program Manager is a ten course program that covers a variety of topics as shown in Figure 1.

- ***ESD Basics for the Program Manager*** describes how static electricity is created, explains the various ways that ESD sensitive devices can be damaged and provides general information on how to protect ESD sensitive devices during handling and product assembly.

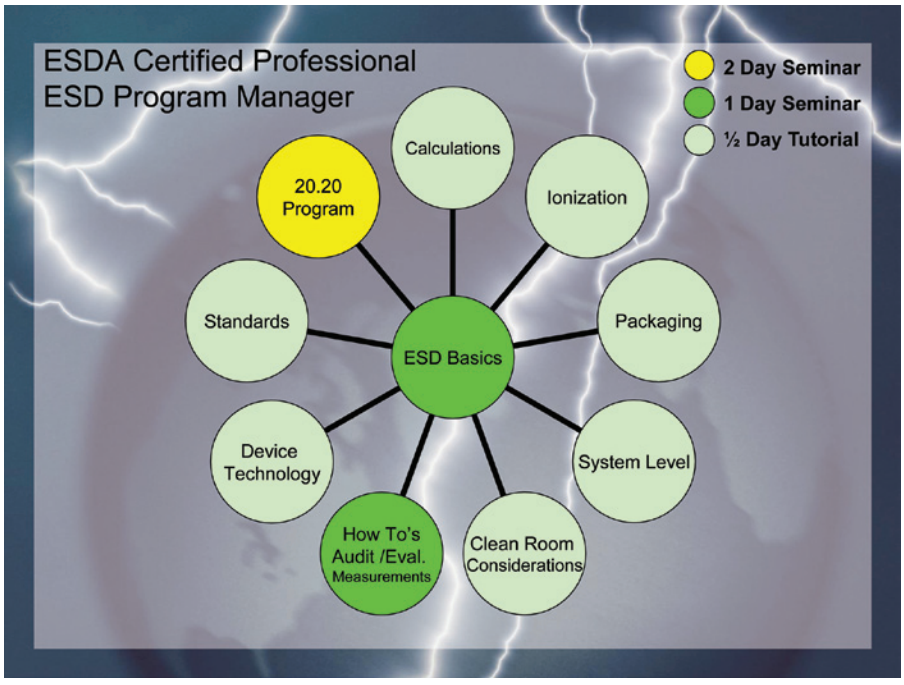


Figure 1: Program Manager ten course certification program

- ***How-To's of In plant ESD Auditing and Evaluation Measurements*** reviews the evaluation and audit measurement procedures required for a S20.20 compliant ESD program.
- ***Ionization Issues and Answers for the Program Manager*** describes the use of air ionization in handling static charge on insulators or isolated conductors in a manufacturing process. It also addresses the major types of ionization systems, their use and the test methods used to verify ionization effectiveness.
- ***Packaging Principles for the Program Manager*** is an overview of the basics of ESD protective packaging used for shipping and storage of ESD susceptible items. It addresses the test methods used to evaluate potential packaging materials, packaging design considerations and the role of packaging in an overall ESD control program.
- ***ESD Standards Overview for the Program Manager*** is designed to provide an overview of the various ESD standards and how they are developed by the ESD Association to meet the needs of the electronics industry. This overview tutorial provides a general review of all the ESD Association documents and should be particularly helpful to program manager candidates just prior to taking the comprehensive exam.
- ***Device Technology and Failure Analysis Overview*** is designed to give a broad overview of ESD device technology, the ways circuit designers protect against ESD, and the failure analysis techniques that are likely to be encountered in reports about ESD failures. The topics covered include the three most common ESD models, characteristics of ideal ESD protection, typical ESD protection schemes, key characteristics of ESD protection, failure analysis flow, and failure analysis tools and their uses.
- ***Electrostatic Calculations for the Program Manager*** focuses on the basic calculations and techniques that would be of use to the ESD engineer and Program Manager. Topics covered include Gauss' Law, capacitance, charge sharing, RC decay, and device failure thresholds.
- ***Cleanroom Considerations for the Program Manager*** addresses how the needs for ESD control and process cleanliness can work together. Cleanrooms and clean environments are required for the

manufacture of many products that have exacting contamination control requirements to achieve defined yield and reliability targets. Clean manufacturing environments are required for the production of items such as semiconductors, hard-disk drives, flat panel displays, and materials for the pharmaceutical industry. Many of the products that require clean processes are susceptible to ESD.

- ***System Level ESD/EMI: Principles, Design Troubleshooting, and Demonstrations*** is intended to help those tasked with testing products to IEC and other system level ESD standards. The student comes out of this class understanding how complex systems are tested for ESD and EMI susceptibility, and some of the common methods used to counter-act system upset and damage due to those mechanisms.
- ***ESD Program Development & Assessment (ANSI/ESD S20.20 Seminar)*** deals with how to develop an ESD control program. The topics covered are training, audit requirements, grounding related to the facility as well as personnel, protected area requirements and packaging, provides information on how to assess an ESD control program based on ANSI/ESD S20.20.

ESDA DEVICE DESIGN CERTIFICATION

The ESDA Device Design Certification is a twelve-course program that provides the attendee with the information required to successfully participate in any ESD device protection design program. Topics are shown in Figure 2.

- ***Overview of ESD and Related Effects for Device/Design*** addresses important issues in the design of IC protection circuits built with advanced deep sub-micron CMOS technologies. This class includes fundamental aspects of ESD protection design such as basic NMOS and SCR concepts, as well as advanced protection concepts.
- ***System Level ESD/EMI: Principles, Design Troubleshooting, and Demonstrations*** This is the same class that is in the Program Manager Curriculum - it is the only overlapping class.
- ***On-Chip ESD Protection in RF Technologies.*** "RF ESD design discipline" is discussed, along with ESD protection in RF CMOS, RF LDMOS, BiCMOS Silicon Germanium, Gallium Arsenide technology and RF silicon-on-insulator (SOI) technology. The tutorial focuses on RF ESD testing, device physics, design layout, circuits and design systems. It provides information on RF ESD testing methodologies, RF degradation effects, and failure mechanisms for devices, circuits and systems.
- ***SPICE-Based ESD Protection Design Utilizing Diodes and Active MOSFET Rail Clamp Circuits.*** There has been a gradual revolution in the world of ESD design for advanced technology CMOS ICs. On-chip ESD networks built with non-snapback ESD devices and circuits, including simple forward biased diodes and active MOSFET rail clamp circuits have increasingly replaced once-prevalent networks built with snapback ESD devices, including avalanche-triggered lateral bipolar transistors and SCRs.
- ***EOS/ESD Failure Models and Mechanisms.*** Failure criteria and failure models associated with semiconductor breakdown, dielectric breakdown, and metal failure will be discussed, associated with the semiconductor industry and nanostructures.
- ***Circuit Level Modeling and Simulation of On-Chip Protection*** addresses modeling and simulation of protection circuit elements and networks under ESD conditions, high current characteristics and transient responses of devices typically used in ESD protection circuits.
- ***Latch-up Fundamentals*** continues to be of interest today in CMOS,

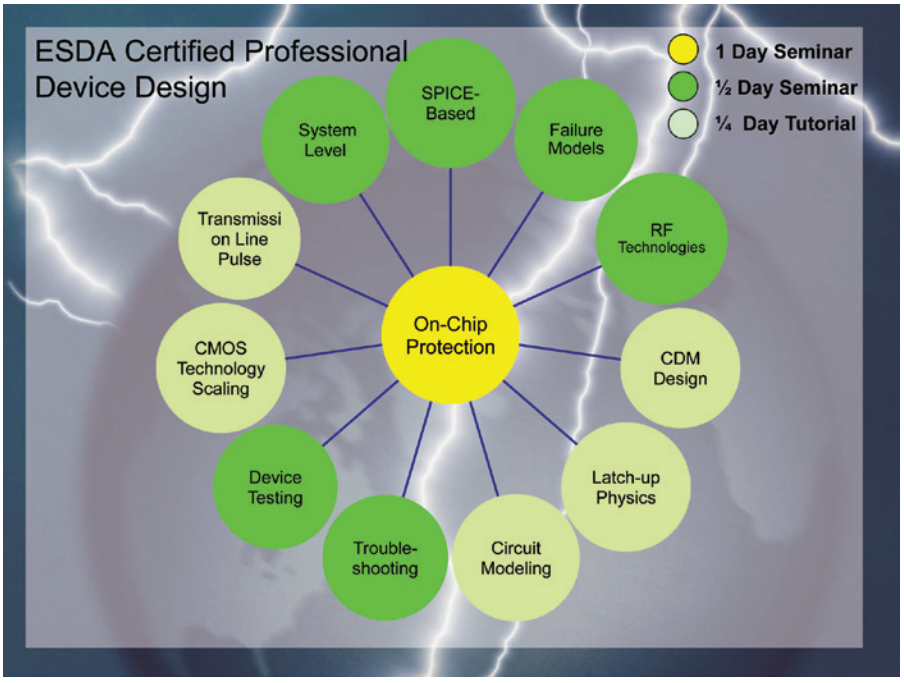


Figure 2: Device Design twelve course certification program

mixed signal (MS) CMOS, RF CMOS, BiCMOS, and BiCMOS silicon germanium. Topics include device-level latch-up physics, latch-up metrics and design criteria, latch-up test structures, test methods, latch-up measurement techniques, device-level CAD simulation, and new latch-up issues.

- ***Troubleshooting On-Chip ESD Failures*** covers diagnosing and fixing on-chip ESD product qualification failures.
- ***Transmission Line Pulse Measurements: Parametric Analyzer for ESD On-Chip Protection*** explores the parameters to be measured with a TLP system and discusses the importance of the parameters in the design of on-chip ESD protection circuits.
- ***Charged Device Model Phenomena, Design, and Modeling*** teaches the basic concepts and ideas required to design-in for Charge Device Model ESD tests.
- ***Impact of Technology Scaling on Components High Current Phenomena and implications for Robust ESD Design*** explores the impact of silicon technology scaling on ESD device behavior and on subsequent ESD protection design. Technology trends for sub-100nm nodes and their implications for the ESD design window will be covered.
- ***Device Testing--IC Component Level: HBM, CDM, MM, and TLP*** addresses the basics of HBM, CDM, MM, and TLP ESD stress testing of the ESD protection structures of ICs.

ESDA DEVICE STRESS TESTING CERTIFICATION

The ESDA Device Stress Testing Certification is ESDA's newest certification program which is offered entirely online. The certification is intended for individuals who are involved in ESD or Latch-up stress testing ranging from qualification to TLP testing for ESD development. This certification ensures that a person has the latest information on the ESD standards used in industry along with an overview of the technical background to perform the tests and understand the results. In addition to learning the recommended test methodologies, a person will be exposed to common pitfalls in interpreting the standards and applying it to the testing procedures used in the lab. The ESD Device Stress Testing Certification program requires the completion of ten, one hour, online courses; this is composed of eight required courses and a choice of two electives.

Required Courses

- ***ESD Fundamentals I for Stress Testing*** This two part tutorial is a condensed version of the ESD Basics for the Program Manager tailored for technicians and engineers who direct or perform ESD stress testing at the device and system level.
- ***ESD Fundamentals II for Stress Testing*** The fundamental properties of charge, electric fields, voltage, capacitance, and current are discussed with a view towards understanding key electrostatic phenomena and electrical processes.
- ***High Speed Digital Oscilloscope Fundamentals*** This tutorial reviews the basic characteristics of oscilloscopes, general use of modern oscilloscopes and their specifications as they relate to ESD measurements.
- ***HBM & MM Testing Essentials*** This tutorial reviews how HBM and MM ESD stress testing are approached from the basic understanding of how the HBM and MM ESD events can occur in the factory and/or the field.
- ***CDM Testing Essentials*** This tutorial

will give students the fundamental information required to quickly learn the CDM testing methods on commercial CDM test equipment and the associated oscilloscope / metrology chain information needed to capture and interpret CDM waveforms.

- ***Essentials for Controlling the ESD Work Area*** This tutorial focuses on the basic components of an ESD controlled work area and how to verify the correct operation of each component.
- ***Fundamentals of Failure Analysis*** This tutorial is targeted toward people doing stress testing on a daily basis where failures are generated and need to be analyzed to determine what failed and how to improve a part's robustness.
- ***Advanced HBM – Dealing with Tester Parasitics, High Pin Count and Two Pin Testing*** This tutorial provides an overview of the joint HBM standard by the ESDA and JEDEC which introduces numerous options to set up the test plan for HBM qualification.

Electives

- ***TLP Fundamentals – Understanding the Equipment Options and IV Data*** This tutorial will explain what Transmission Line Pulsing (TLP) is and how it can be used for ESD design and development.
- ***Fundamentals of System Level Testing*** This tutorial provides an understanding of how testing done at the system level is essential to understanding the stress that will be applied to a device installed in the final product.
- ***Latch-up Testing and Troubleshooting*** This tutorial will help the student to understand the issues related to latch-up, ways to prevent it and methods used for verifying latch-up resistance in products.
- ***VF-TLP, An Introduction to Capabilities and Applications*** This tutorial explains the VF-TLP measurement setups, equipment options and how the extracted data is interpreted.
- ***HMM – System Level Testing of Components*** This tutorial will explain in detail the intent of the HMM standard test method. The tutorial will also provide some data to show the

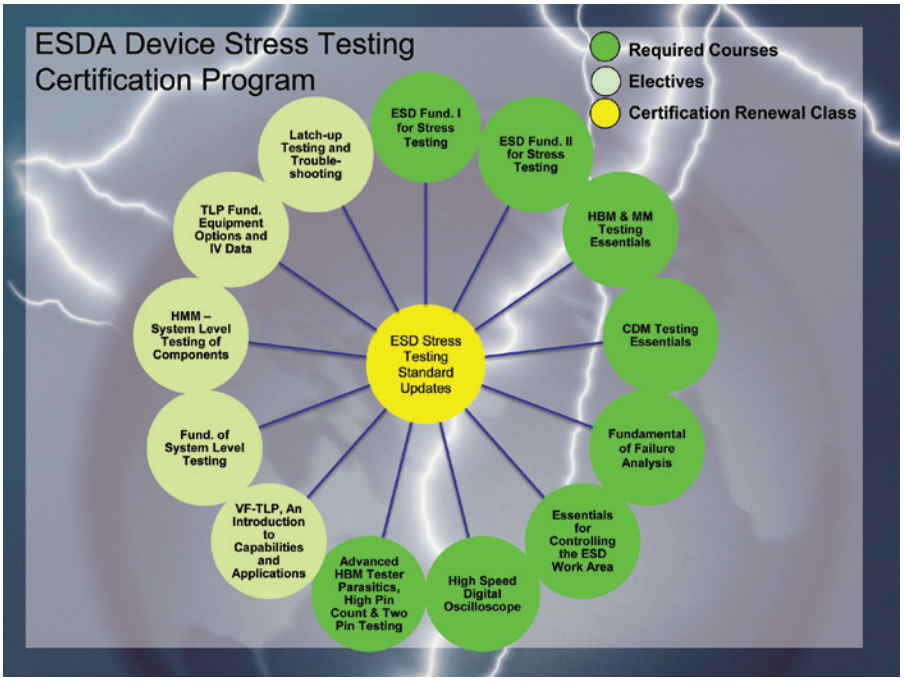


Figure 3: Device Stress Testing certification program

CONCLUSION

Becoming certified is not a task to be taken lightly. Taking the time to learn all of the material and putting the knowledge into practice is equally important (and of course necessary) to passing applicable exams. The exams for ESDA Program Manager Certification and ESDA Device Design Certification are extensive and formulated to test not only knowledge of the material but general understanding of the principles involved in maintaining ESD control. The level of confidence obtained with a full understanding of the course materials will prove invaluable to you, your employer and your colleagues with measurable improvements that will be evident in your ESD control processes or designs. Component sensitivity to ESD will continue to increase dramatically over the next few years for all electronic parts. Device design and in-plant processes must improve to avoid costly losses. Education of employees involved in the ESD control programs, device design, and testing is vitally important to success. Becoming certified is a badge of excellence to be displayed for all to see. Start your certification today! IN

About the EOS/ESD Association, Inc.

Founded in 1982, the EOS/ESD Association, Inc. is a professional voluntary association dedicated to advancing the theory and practice of electrostatic discharge (ESD) avoidance. From fewer than 100 members, the Association has grown to more than 2,000 throughout the world. From an initial emphasis on the effects of ESD on electronic components, the Association has broadened its horizons to include areas such as textiles, plastics, web processing, cleanrooms, and graphic arts. To meet the needs of a continually changing environment, the Association is chartered to expand ESD awareness through standards development, educational programs, local chapters, publications, tutorials, certification, and symposia.

IEEE 10th Annual IEEE Symposium on

Product Compliance Engineering

PSES Product Safety Engineering Society

October 7-9, 2013 | **THE WESTIN AUSTIN AT THE DOMAIN**

Austin, TX

Exhibiting at the show

The Symposium provides the perfect venue to reach qualified buyers for product safety related products and services! People attending our Symposium are:

- **Certifiers and Regulators**
- **Product Safety Managers and Engineers**
- **Regulatory Managers and Engineers**
- **Test Laboratory Managers and Engineers**

Contact Sue Kingston for Exhibit details -
skingston@conferencecatalysts.com

Featured Tracks

EMC Track
Forensics Track
Lithium Ion Batteries Track
Leadership Track
ITE Product Compliance Track
Medical Devices Track
Risk Assessment Track
General Track

Keynote Speaker

Joe Bhatia
President and CEO of ANSI
(American National Standards Institute)

Registration is now open!

To register for 10th Annual ISPCE Symposium, please visit the registration page at **http://www.pesessymposium.com/**

For general inquiries, contact Kimberly Milne -
kmilne@conferencecatalysts.com

Venue

ISPCE 2013 will be held at the Westin Austin at the Domain

Single/Double Rate: $149
Reservations at this rate can be booked until September 14, 2013.

Please visit
http://www.psessymposium.com/
to make your reservation today!

REALITY Engineering

Timbuktu (or Bust)

BY MIKE VIOLETTE

Bamako, a tattered town on the Niger River, is the home of the US embassy in Mali. It being the capital, the city has offices for various aid agencies (IMF, World Bank, etc.) as well.

Embassies and these other facilities typically house SCIFs and spooky equipment for monitoring and communications. SCIF or "Sensitive Compartmented Information Facility" (I had to look that up) is a fancy name for a big metal box.

Once upon a time, we got a call to run some shielding effectiveness measurements on the facility. I said 'heck yah', never been to Mali, much less any part of Joseph Conrad's *Heart of Darkness* continent. The upgrading of the Embassy there a result of Mali's rise in the developing mid-section of Africa, where any hint of stability is welcome.

Mali is twice the size of her former dominatrix, France, a land-locked mostly-desert country tucked under the Sahara desert. She was once a jewel in the Spice Trade routes a millennium ago and since 1960 an unshackled colony of Gaul. After a rocky start on the road to independence (typical for former colonies of western powers) things in Mali stabilized and for much of the 2000s, Mali was hailed as a bellwether for Central African developing nations, with a democratically elected government. Aid agencies focused on programs to raise the three-dollar per day per capita income and things seemed to be working, for a while.

Timbuktu is way out there in the barren northeast corner of the country (in the *Tombouctou* region), at about the same latitude as Cuba, but far from having a lush semi-tropical climate. (It is so removed that it took Googlemaps about five minute to load up an image. It looked like I had accidentally stumbled on pictures from the Mars Rover landing.)

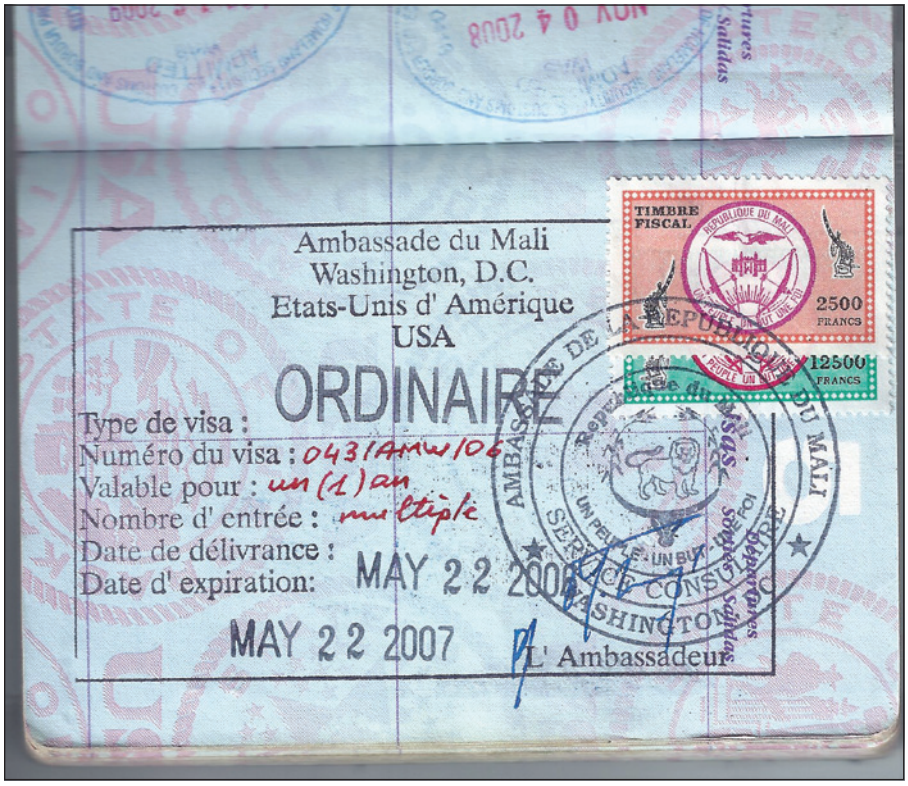
There are very few routes to Timbuktu, roughly three, not counting slogs across sandy dunes, although in the 15th and 16th centuries it was the crossroads of a lively trade route.

Getting into Mali requires a Visa, of course and shots. I headed down to the local travel clinic and Dr. Nichols guided me through a bunch of pamphlets on travel to Africa. "Let's see, the Center for Disease Control recommends inoculation against the following: yellow fever, hepatitis A, malaria, polio and optionally hep B, meningitis and rabies." She paused. "Do you plan to do any caving? The bats are rabies carriers."

I was decidedly not planning on any caving and skipped the optional vaccines. She wrote me a couple of prescriptions. "Take these over to Erin and she'll fill them out." Thanks Doc.

I walked around the corner to the pharmacy window and asked for Erin. A comely blonde smiled at me. "Erin's out at an anime convention. I'm Sharon. What do you need" She took the slips of paper and in exchange gave me a couple of bottles of pills. Thus provisioned, I begin a regimen of yellow fever and malaria, a course of capsules taken a few weeks prior to wheels-up (a visit to China a few years back gave my liver some hep A protection).

The trip to Bamako was scheduled for the actual work and I framed out



It was 2007 when we were called to do the shielding work in Bamako. Things were not exactly a garden party back then, but less dicey than now, particularly for a Yankee engineer. Unfortunately, the schedule for the testing shifted by a precious week, colliding with the trip to China. I still have the (unused) visa.

a few days on the calendar to get up to Timbuktu, which, it turns, out ain't easy. The roads are hazardous and the flights are few. One compelling option was a boat ride up the Niger River, the lifeblood of arid Mali. Three days, but I figure it would be a good bucket-lister. The only potential cramp was a back-to-back trip to Beijing, which was on the heels of this trip.

The great Mosques and mausoleums of Timbuktu, dating from the golden age of the city, house the writings and bones of many a Malian and stranded travellers. The ancient city, a UNESCO world heritage site, is slowly being eaten by the Sahara.

There are other, more immediate threats, however.

For much of 2012, rebellion in northern Mali by the Tuaregs (supported by scattered veterans of Libyan liberation battles and assorted Al-Qaeda sponsored groups) effectively divided the not-so-very united country into two regions: one controlled by the Tuaregs and their uneasy extremist allies in the north and the other under a weak central government in the south.

The failure to quell the rebellion forced the failure of the government of President Amadou Toumani Touré (2002-2012), under a classic African coup d'etat (led by Army Captain Sanogo). Under outside brokerage, Mr. Dioncounda Traoré was installed as President. He, though, suffered his own bit of humiliation when supporters of a rival faction attacked him, stripped him naked gave him a big whack on the head. He eventually returned. The French came in, beat back the rebellion sufficiently for the central government to stabilize.

Which brings me back to Timbuktu—or not. It was 2007 when we were called to do the shielding work in Bamako. Things were not exactly a garden party back then, but less dicey than now, particularly for a Yankee engineer. Unfortunately, the schedule for the testing shifted by a precious week, colliding with the trip to China, the reason for which is a blank memory. I still have the (unused) visa. Perhaps, when things quiet down, I'll get it renewed and get the Timbuktu T-shirt (and probably a whole lot more, but skipping the malaria and yellow fever, hopefully).

Close, but no cigar. Even on the road to Timbuktu the reality of engineering is that not all plans come to the fore. IN

(the author)
MIKE VIOLETTE
is President of Washington Labs and Director of American Certification Body (mikev@wll.com). Mike still has this unique city on his Timbuket-list.

EVENTS in Compliance

August 2013

20-22
Fundamentals of Random Vibration and Shock Testing
Equipment Reliability Institute
Santa Barbara, CA
www.incompliancemag.com/events/130820

September 2013

8-13
35th Annual EOS/ESD Symposium & Exhibits
ESD Association
Las Vegas, NV
www.incompliancemag.com/events/130908

10
Understanding Ground Resistance Testing
AEMC Instruments
Philadelphia, PA
www.incompliancemag.com/events/ 130910_1

10-11
Fundamentals of Applied EMC Engineering
UL Knowledge Services
Jacksonville, FL
www.incompliancemag.com/events/130910_2

10-13
MIL-STD-461F
WL Academy
Gaithersburg, MD
www.incompliancemag.com/events/130910_3

16-20
Introduction to Antenna Pattern Measurement (APM) & Wireless Over-The-Air (OTA) Testing
ETS-Lindgren
Austin, TX
www.incompliancemag.com/events/130916

17
International Approvals Briefing for China/Taiwan
TÜV Rheinland
Pleasanton, CA
www.incompliancemag.com/events/130917_1

17-19
Measurement, Control and Laboratory Use Equipment: Designing for Compliance to IEC 61010-1 3rd Ed.
UL Knowledge Services
Jacksonville, FL
www.incompliancemag.com/events/130917_2

18
BRIC Through The Emerging Markets
SIEMIC
Milpitas, CA
www.incompliancemag.com/events/130918

19
International Approvals Briefing for China/Taiwan
TÜV Rheinland
Boxborough, MA
www.incompliancemag.com/events/130919

24-26
Designing to Comply with IEC 60601-1, 2nd & 3rd Editions
O'Brien Compliance Management, LLC
Amsterdam
www.incompliancemag.com/events/130924_1

24-26
Electromagnetic Compatibility Engineering
University of Michigan-Dearborn
Dearborn, MI
www.incompliancemag.com/events/130924_2

October 2013

1-4
High Intensity Radiated Fields (HIRF) Course
Oklahoma State University
Stillwater, OK
www.incompliancemag.com/events/131001

2
Understanding Ground Resistance Testing
AEMC Instruments
Palm Springs, CA
www.incompliancemag.com/events/131002

6-11
35th Annual Symposium of the Antenna Measurement Techniques Association (AMTA)
Antenna Measurement Techniques Association (AMTA)
Columbus, OH
www.incompliancemag.com/events/131006

7-9
IEEE Symposium on Product Compliance Engineering
Product Safety Engineering Society
Austin, TX
www.incompliancemag.com/events/131007

8-9
EMCUK 2013
Newbury, Berkshire
United Kingdom
www.incompliancemag.com/events/131008

EVENTS in Compliance

15-17
MIL-STD 461F
ETS-Lindgren
Austin, TX
www.incompliancemag.com/events/131015

21-24
Military Standard 810G (MIL-STD-810G) Testing
Dayton T. Brown
Bohemia, NY
www.incompliancemag.com/events/131021

22-24
Designing to Comply with IEC 60601-1, 2nd & 3rd Editions
O'Brien Compliance Management, LLC
North Chelmsford, MA
www.incompliancemag.com/events/131022

23-25
EMC/China 2013
Shanghai Everbright Convention & Exhibition Center
Shanghai, China
www.incompliancemag.com/events/131023

28-31
Hands-On Power Supply Design
Ridley Engineering
Cambridge, United Kingdom
www.incompliancemag.com/events/131028

PRODUCT Showcase

Your Source for Product and Service Solutions

(Authors)

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.

Ken Javor
has worked in the EMC industry over thirty years. He is a consultant to government and industry, runs a pre-compliance EMI test facility, and curates the Museum of EMC Antiquities, a collection of radios and instruments that were important in the development of the discipline, as well as a library of important documentation. For more about Ken, please visit page 91.

Niels Jonassen, MSc, DSc,
worked for 40 years at the Technical University of Denmark, where he conducted classes in electromagnetism, static and atmospheric electricity, airborne radioactivity, and indoor climate. Mr. Jonassen passed away in 2006. For Mr. Jonassen's full bio, please see page 20.

Fred Kozlof
is currently with CONEC. Fred was involved with commercial filter connector design back when the FCC regulations were implemented!

Eddie Pavlu
was most recently Vice President of Operations at National Technical Systems. Prior to that he was President and CEO of Elliott Laboratories. He has a Bachelors and Masters degree in Electrical Engineering, and has been in executive management for the past 16 years. For more about Eddie, please visit page 68.

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. For Mark's full bio, please see page 25.

Mike Violette
is President of Washington Labs and Director of American Certification Body (mikev@wll.com). Mike still has this unique city on his Timbuket-list.

Paul Wang
works for G&M Compliance Inc. as technical director mainly focus on China certifications. He is also on the Board of Directors of IEEE Product Safety Engineering Society. For more about Paul, please visit page 94.

CONSULTANTS Corner

(Advertisers)

Advertiser Name	Page
2013 IEEE EMC Symposium	26
2014 IEEE EMC Symposium	32
A.H. Systems	C2
AMTA 2013	103
AR	9
Advanced Test Equipment Rentals	57
Agilent Technologies	65
CST of America, Inc.	87
Compliance Worldwide	83
Dexmet Corporation	11
Don HEIRMAN Consultants	113
Dutch Microwave Absorber Solutions	67
E. D. & D., Inc.	85
EM Test USA	15
ETS-Lindgren	C3
Eletronics Test Centre	81
Fair-Rite Products Corp.	23
HV TECHNOLOGIES, Inc.	21
Henry Ott Consultants	6/7, 113
IEEE EMC Minnesota Event	105
IEEE Product Safety Engineering Society	107
Kimmel Gerke Associates Ltd	113

Advertiser Name	Page
Monroe Electronics	111
The MuShield Company, Inc.	99
Nemko USA	95
Oak Mitsui Technologies	77
Panashield, Inc.	17
Pearson Electronics Inc.	19
Phoenix Technical Group	111
Product Safety Consulting, Inc.	113
Quell Corporation	79
Rigol Technologies	25
Rohde & Schwarz	61
Schurter	63
Siemic, Inc.	111
Spira Manufacturing Corporation	3
Swift Textile Metalizing LLC	91
TRU Corporation	13
TÜV Rheinland	59
Teseq	C4
Timco Engineering, Inc.	89
Washington Laboratories Academy	62
Wyatt Technical Services LLC	113

See What's New at ETS-Lindgren!

Visit our booth in Denver and let us roll out the red carpet for you!

We'll be showcasing new products and demonstrating new solutions. Our industry experts will be available to answer your questions. TILE!™ lab management software users can also join us for our annual TUG breakfast and learn about the latest enhancements for improving test productivity.

So stop by Booth #401 and let us treat you like the VIP you are!

ETS·LINDGREN®
An ESCO Technologies Company

www.ets-lindgren.com

Offices in the US, Brazil, Germany, Finland, UK, France, India, Japan, Singapore, China, Taiwan

TESEQ, IFI & MILMEGA –
THE NEW BRAND TO REMEMBER!

Three strong brands joined forces in 2012 under the Teseq umbrella to offer the industry's widest product range: Teseq, IFI and Milmega!

Our product portfolio includes Milmega's famous solid state microwave amplifiers, Teseq's rugged Class A power amplifiers and IFI's high power RF solid state and Tetrode tube amplifiers, as well as their well-known TWT amplifiers up to 40 GHz. Teseq now covers any application in the EMC, telecommunications and defense industries.

Our strong global service network with local accredited calibration labs ensures fast turn-around for calibration and repair. We back our commitment to quality and reliability with a warranty up to 5 years.

Teseq – IFI – Milmega, the new power amplifier team to remember!

What we offer:

- **Amplifiers for EMC, ISM, telecom and defense**
- **Solid-state class A and class AB models**
- **CW, pulsed and combined TWT amplifiers**
- **Tetrode tube amplifiers**

What makes us unique:

- **Rugged, reliable design for EMC testing with any load**
- **Higher power at lower frequency to compensate for antenna gain**
- **Compact design with modular architecture**
- **Up to 5 years warranty**
- **Local service through Teseq's own service organizations**

Teseq Inc. Edison, NJ USA
T + 1 732 417 0501 F + 1 732 417 0511
usasales@teseq.com www.tesequsa.com

a TESEQ Company

MILMEGA
a TESEQ Company

TESEQ
Advanced Test Solutions for EMC