

KIMMEL GERKE



Bullets



Summer, 2002

Welcome to KGB...

And to this issue of our "personal communications" to our friends, clients, and colleagues about EMI issues, problems and solutions.

This KGB discusses "Avionics EMC," a topic of great personal interest to all of us who travel a lot by air. We are happy to report that all the avionics designers we know are VERY conscientious about EMI in aircraft.

We have dealt with numerous "avionics EMC" issues in the past few years, both military and commercial. Radiated emissions are a big concern, with "worst case" levels 40-50 dB below the commercial limits. Immunity is also a big concern, including high RF levels, power disturbances, and lightning. The requirements are tough and challenging — more similar to automotive than commercial requirements. As a result, many "standard" EMC approaches are inadequate for avionics.

As we have done in past issues of the KGB, we will briefly share our EMC perspectives and experiences about this important industry. As always, give us a call if we can help with your EMI problems... avionics, military, commercial, medical, industrial, telecom, automotive, or ???

Best Regards... Daryl Gerke, PE, and Bill Kimmel, PE.

New EMC Seminar Format

Based on student feedback, we have changed our class formats. This allows us to eliminate overlap, and include more NEW INFORMATION as well.

– **EMC Grounding & Shielding (2 days)** – Covers grounding, shielding, power (both power supplies and power quality), cables & connectors, RFI, ESD, emissions, and more. Addresses BOTH systems and equipment design issues.

– **EMC/SI in Printed Circuit Boards (1 day)** – Covers PCB design for EMC and Signal Integrity. Addresses ONLY circuit and circuit board issues.

Which classes to take? Here are our suggestions:

- Design equipment – include PCBs? All THREE DAYS.
- Design/install systems – no PCBs? TWO DAYS.
- Design ONLY Circuit Board? ONE DAY.

Shows and Conferences...

Here are some shows and meetings we are involved with that may be of interest. Call us if you'd like more details.

IEEE EMC Symposium... August 19-23, 2002, in Minneapolis, MN. This is the first time this show has been held in the "Twin Cities." Both Bill and Daryl will give a one hour talks during the Monday tutorial sessions. Bill's talk is on "Medical EMC Issues," and Daryl's talk is on "Designing for RF Immunity." In addition, Bill and Daryl will each be hosting technical sessions.

You don't need to be an "EMC-expert" to benefit from this show. There are tutorial sessions on Monday and Friday, and informative EMC demonstrations throughout the week. For more info, visit www.2002-ieee-emc.org. August is the ideal time of year to visit Minnesota... hope to see you.

Tektronix Sponsored EMC Seminars...

Here are the cities for the Fall 2002 schedule for the EMC seminar series sponsored by Tektronix, and conducted by Kimmel Gerke Associates, Ltd. For more information, visit our web site at www.emiguru.com.

– **Denver, CO - September 16-17-18, 2002**

– Courtyard by Marriott, Louisville, CO

– **Seattle, WA - September 23-25-26, 2002**

– Clarion Inn at Totem Lake, Kirkland, WA

– **Phoenix, AZ - October 7-8-9, 2002**

– Embassy Suites, Tempe, AZ

– **Detroit - October 15-16-17, 2002**

– Hotel Baronette, Novi, MI

– **Minneapolis, MN - October 21-22-23, 2002**

– Hampton Inn, Bloomington, MN

– **Chicago, IL - October 28-29-30, 2002**

– Hampton Inn, Schaumburg, IL

– **Santa Clara, CA - November 6-7-8, 2002**

– Courtyard by Marriott, San Jose Airport, CA

– **Los Angeles, CA - November 11-12-13, 2002**

– Courtyard by Marriott, Irvine, CA

Please note the NEW FORMAT, described in the box to the left. *By the way, four or more from the same company qualify for a 10% discount.* These classes have been sponsored by Tektronix since 1993, and are very popular. *You may register on-line at www.emiguru.com.* These classes are also available in-house — if you have 10 or more students, it often makes sense to hold an in-house class.



Focus on "Avionics EMC"...

We've dealt with quite a few "avionics" EMC issues in the past several years. These have ranged from doing design reviews (circuit boards to systems) to climbing around aircraft with sniffer and current probes checking out cables for emissions. One experimental system was so "noisy" that the VHF communication receiver was unusable at 132 MHz, due to the harmonics from a 12 MHz clock.

EMC in aircraft is taken quite seriously, since critical communications or navigation functions could be affected. Suspected EMC incidents are reported to the FAA for further investigation. Some recent incidents are believed due to passengers using cell phones or radio receivers in flight — both violations of both airline policies.

We are happy to report that all the avionics designers we know take EMC very seriously. To those of you who work in this area, we commend you. To those of you who move into avionics from the commercial areas — welcome to the world of some really tough and challenging EMC problems. Here are some general comments and observations on dealing with EMC in avionics.

Regulatory requirements — There are two common sets of EMC test requirements for avionics. For military aircraft, MIL-STD-461E is the key military EMC specification. For commercial aircraft, RTCA DO-160D is the comparable EMC specification.

MIL-STD-461E — As a generic requirement, this document addresses a wide range of environments. The specific requirements are defined as part of a procurement contract. These include radiated and conducted emissions (RE, CE), and radiated and conducted and susceptibility (RS, RS).

If the equipment is a radio transmitter or receiver, there may be additional requirements regarding intermodulation or spurious emissions. Nuclear EMP (electromagnetic pulse) requirements may also be imposed.

DO-160D — This document from the RTCA (Radio Technical Commission for Aeronautics) applies specifically to commercial avionics. As such, it is a bit more definitive than MIL-STD-461. Many of the DO-160 requirements are derived from MIL-STD-461, so there are similarities in the general RE/CE/RS/CS requirements. DO-160 also addresses lightning, power quality, and ESD (electrostatic discharge) effects on avionics.

A KGB Bullet...

Here is a formula that shows the variables that affect the impedance of a ferrite:

$Z \text{ varies as } L N^2 \log_{10} (OD/ID)$, where

Z = ferrite impedance

L = ferrite length

N = number of turns through core* (Usually <3)

OD = outer diameter, ID = inner diameter

Note: More turns increases low frequency impedance, but decreases high frequency impedance.

In recent years, some avionics customers have "tailored" DO-160, making the requirements even more stringent. A key example is the radiated emissions "notch" between 100-150 MHz. This is aimed at protecting the commercial aircraft communications and navigation frequencies between 108 and 135 MHz. Several other narrow notches may be imposed as well. The RE levels in the notches are well below comparable military RE levels. As a result, these "notch" levels can have severe design impact.

Problem areas — Here is a quick overview of some of the EMC problems of concern in the aircraft environment, and their impact on designs.

— *Radio transmitters and receivers* — Most aircraft have a number of onboard transmitters and receivers, including HF/VHF/UHF communications, navigation, radar, and transponders. All these systems must reliably work together in a demanding environment.

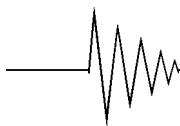
Transmitters can create local high levels of RF energy that can adversely affect other electronics. They can also interact resulting in intermodulation (IM) products at unwanted frequencies. Radio receivers, and sensors and instruments, are particularly vulnerable to these RF levels. At the same time, on board radio receivers are looking for very small signals, and are vulnerable to "jamming" from both intended sources (such as transmitters) and unintended sources (such as computer based systems.)

To further complicate things, external transmitters can also pose problems. Examples are ground based radar systems, or local land mobile transmitters. An insidious problem is local oscillator (LO) leakage from passenger AM/FM/TV receivers. For example, on some FM receivers the LO tunes through the 108-118 MHz range, which could jam intended VOR navigation signals in this frequency range.

— *General electronics* — Most modern aircraft are "flying computer and control" systems. These range from sophisticated flight control computers to embedded microcontrollers in passenger entertainment electronics.

Digital systems are rich sources of unwanted emissions that can jam communications receivers. They are also vulnerable to "spike" interference, such as ESD or transients. Analog systems, particularly low level sensors, are vulnerable to jamming from high levels of RF energy.

— *Lightning, ESD, and Power Glitches* — These three threats are present on all aircraft, and must be addressed during design. Lightning is particularly nasty, since sooner or later, any aircraft will be hit by lightning. A few years back, Daryl was in a plane hit by lightning. Suffice it to say, it was a memorable EMI event. The aircraft was unaffected, however, a tribute to good EMC design.



Design Solutions – Equipment level solutions include filtering, shielding, and careful attention to circuit boards to reduce radiated emissions. Power and I/O interfaces need to be hardened to meet lightning, ESD, and power disturbance threats. Sensors may need additional hardening to operate at high RF levels.

At the systems level, solutions include care in cable routing, and attention to grounding and bonding. For radio receivers, additional solutions include intermodulation analysis, frequency management, and careful location of radio receiver antennas.

Incidentally, our experiences shows many airframe builders do a poor job on high frequency cable shielding. They persist in using "pigtailed" to terminate the shields, which render high frequency shielding useless. As a result, equipment designers usually need to provide extensive high frequency filtering on I/O and power interfaces to compensate for these cable deficiencies.

In closing, we hope this has given you some useful insights into avionics EMC problems and solutions. If you need help with these issues, or any other EMC issues, please contact us at 1-888-EMI-GURU, or through our web site at www.emiguru.com.

Let us all be happy and live within our means, even if we have to borrow the money to do it with.

– Artemus Ward, *American Humorist*, 1866

More graffiti... PPPPPP...

In the last issue, we had the "Seven Fs", and extended the challenge for more. Troy Schelling offered the "Six Ps"... *Prior Planning Prevents P*** Poor Performance*. (Got one to share?... send it to dgerke@emiguru.com.)

Things you can learn from a dog...

When we saw this, we realized there was a lot of wisdom (as well as humor) in these words:

- Never pass up the opportunity to go for a joyride.
- When loved ones come home, always run to greet them.
- Let others know when they have invaded your territory.
- Run, romp, and play daily.
- Eat with gusto and enthusiasm.
- Be loyal.
- Never pretend to be something you are not.
- If what you want lies buried, dig for it.
- Avoid biting when a growl will do.
- On hot days, drink lots of water and lie under a shady tree.
- When you're happy, dance around and wag your body.
- Delight in the simple joy of a long walk.
- No matter how often you're scolded, don't buy into the guilt thing and pout... run right back and make friends.
- When someone is having a bad day, be silent, sit close by, and nuzzle them gently.

(From *73 Amateur Radio Today*, July 2002)

Book Reviews...

Electromagnetics Explained, by Ron Schmitt. Dubbed a "*Handbook for Wireless/RF, EMC, and High Speed Electronics*", the author pulled together a bunch of concepts in electromagnetics, and related them to real world problems. We found it a very refreshing (and useful) approach. Easy to read with lots of good stuff.

Just released by Newnes in 2002, as part of the "EDN Magazine Series for Design Engineers." For more info: www.ednmag/bookstore.com. ISBN 0-7506-7403-2.

Signal Integrity & EMC...

For a quick introduction to the interrelationship between these two important topics, see our recent article titled "*The Return Path: Impedance Control on Printed Circuit Boards*," which appeared in the **Compliance Engineering 2002 Annual Reference Guide**.

If you don't receive this important magazine, go to www.ce-mag.com to sign up. It is free to qualified subscribers. If you are working on Signal Integrity and/or EMC problems, you are certainly "qualified."

EDN Designer's Guide to EMC...

The updated version of this popular guide (written entirely by Bill & Daryl) is available from Cahners Publishing. The update includes two new chapters, plus new regulatory information. Strongly recommended for anyone just starting out in EMC.

Cost is \$49.95, with quantity discounts. To order, go to our web site, www.emiguru.com, and click on the icon for the *EDN Magazine Designer's Guide to EMC*.

Engineering "Rules"...

Daryl had an engineering professor who was fond of quoting engineering "rules", mostly to make the students think. Over the years, two have stuck in memory:

- *You can't push on a rope.*
- *You can't tell how deep a puddle is from the top.*

How about you? Do you have some "rules from the past" that you would like to share? Send them in, and we'll print them (the printable ones) in a future issue of the KGB. Just e-mail them to dgerke@emiguru.com.

Copyrights and Trademarks...

While we are happy to share EMC information via our newsletters and web site, we have had some unfortunate "piracy" recently of our copyrights and trademarks. In one case, an entire copyrighted web page was plagiarized, and in another, our *EMIGURU*® trademark was infringed. We are disappointed to see this unprofessional and unethical behavior occur in the EMC community.

By the way, you are always free to reproduce the KGB intact, as noted in our copyright notice. You can also make brief excerpts as long as you quote the source. Thanks.



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Web Site... Please visit our web site (www.emiguru.com) for class schedules, back issues of the KGB, and other useful EMI stuff. We've also included detailed information on our firm, such as our consulting and training brochures.

EMI Suppression Handbook...

The little red book with the great EMI war stories, written by us, and edited by our good friend, Dr. Tom Chesworth. Only \$25 plus shipping. To order, contact Seven Mountains Scientific at 814-466-6559, or visit their secure website at www.7ms.com.

EMI-Toolkit® 2.0...

Check out the updated version of our popular *EMI-Toolkit®* software. The new version includes many useful features, plus an improved format. Comes on CD, and runs under Windows 95/98/NT/2000/XP. \$150 single user, \$750 for site license. Discounts apply for V1.0 users.

If you are heavy into the EMC standards, consider *EMI-Toolkit® Plus*. All the neat features of V2.0, plus additional information on most relevant EMC standards (MIL-STD-461, DO-160, FCC, CISPR, and more...)

For more information on either version, call us at 1-888-EMI-GURU, or e-mail bkimmel@emiguru.com*

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