KIMMEL GERKE Bullets

EMI GURU®

Winter 2010/2011

Welcome to KGB...

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

This issue focuses on radiated emissions, one of the most common and yet most important EMI issues we all face. Without reasonable limits on radiated emissions, vast frequency ranges would be unusable to licensed users of the RF spectrum. This is why the FCC, military, and other agencies around the world have promulgated their radiated emissions requirements.

In short, this is a massive electronic pollution problem. Just think of a world without cell phones, wi-fi, aircraft navigation, public safety communications, and talk radio (OK, maybe we could do without the last one....)

Happy Holidays, and all the best to you and your families now and in 2011! As always, give us a call if you need EMI help.

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

FREE Copy of Useful Bits of Info...

Want your own copy "UBI," the little shirt pocket sized "cheat sheet" for EMI? Just e-mail *dgerke@emiguru.com*, with your snail mail address, and we'll send you one.

EMC Winter Workshops 2011

Orlando, FL - February 7-8-9, 2011
San Diego, CA - February 22-23-24, 2011

Need a winter break, and some fun in the sun? Want to learn more about EMC design or troubleshooting? Then join us in Orlando or San Diego for our annual *EMC Winter Workshops.*

In addition to our regular *Design for EMC* class (2 days), you can attend our *EMC Troubleshooting* class (1 day). The troubleshooting class is offered ONLY at these locations, as an optional extension to the two day class. If you have already attended a two day class, you are welcome to join us for this additional day.

For more details, visit our website (*www.emiguru.com*) or call us toll free at 1-888-EMI-GURU. (Inquire about our special hotel rates in Orlando.)

Public EMC Classes...

Here are the cities for the Winter/Spring 2011 schedule for the EMC seminar series co-hosted by Tektronix and Kimmel Gerke Associates, Ltd.

- **Orlando, FL - February 7-8-9, 2011**
  Best Western Lakeside, Kissisimme, FL
- **San Diego, CA - February 22-23-24, 2011**
  Arrow Electronics Inc., San Diego, CA
- **Dallas, TX - March 22-23, 2011**
  Tektronix Regional Office, Plano, TX
- **Boston, MA - April 5-6, 2010**
  Courtyard by Marriott, Marlborough, MA
- **Baltimore, MD - April 11-12, 2011**
  Courtyard by Marriott (Ripkin Stadium), Abderdeen, MD
- **Rochester, NY - May 2-3, 2011**
  Courtyard by Marriott, Greece, NY

For more information on any of these locations, please visit our web site, *www.emiguru.com*. Call for discounts for multiple students (4 or more).

For larger groups, (12 or more students,) it often makes sense to hold an in-house class. These are done at a fixed cost, with up to 30 attendees. This can really drop the cost per student. You can even co-share with another company -- we've had several firms do this in the past.

Visit Our New Web Site...

By the time you read this, our "remodeled" web site should be up and running. Easier to navigate, new resources, and even more in the near future. Some things free, others for a nominal fee. Here are some examples of the updates:

- -- *EDN Designer's Guide to EMC* , Order on-line ($$).
- -- *E-Book*, The out-of-print "EMI Suppression Handbook" available for download. ($$).
- -- *EMI-Toolkit (TM) Software,* Available for download ($$)
- -- *Past KGB's*, All 20 years now in PDF files (FREE)
- -- *EMI Bibliography* , Updated (FREE)
- -- *Blog*, Our thought and comments on EMI issues (FREE)
- -- *Webinars* , Select topics (Both FREE and $$)

All of these are part of our ongoing educational efforts to share our EMI knowledge and experience (over 80 years between us.) Please visit us at *www.emiguru.com.*

Kimmel Gerke Bullets is a free newsletter on Electromagnetic Interference/Compatibility (EMI/EMC).
Published by Kimmel Gerke Associates, Ltd., 628 LeVander Way, S. St. Paul, MN 55075 • 1-888-EMI-GURU • http://www.emiguru.com

Focus on Radiated Emissions...

The genesis of EMI began with "radiated emissions" (RE) jamming radio receivers. In fact, the original common term for EMI was "RFI" for "radio frequency interference."

A short history... The first RFI problem probably goes back to Marconi, with his massive spark gap transmitters that effectively sprayed energy across the RF spectrum. This was soon followed by miniature spark gap sources in the form of vehicular ignition systems. These resulted in the first military EMI specification (SLC-49 - "Electrical Shielding and Radio Power Supply in Vehicles") issued by the US Army Signal Corps in 1934.

As radio receivers proliferated, however, so did the RE problems. The military was particularly concerned, and continued to update RFI specifications. In 1945, the first joint Army-Navy specification was issued (JAN-I-225), which still focused on RE levels from 150 kHz to 20 MHz. The goal continued to be to protect radio receivers.

It was only later that susceptibility issues were included, with the goal of protecting electronic equipment and systems from other EMI threats in the environment (power disturbances, ESD, RF from nearby transmitters, etc.)

RE problems today... No, the RE problems haven't gone away. In fact, with the proliferation of communications and wireless devices, they have only become worse. There are more sources combined with more victims in closer proximity to each other. The good news is that this assures future employment opportunities for engineers familiar with EMI design and mitigation techniques (including EMI consultants, of course.)

RE concerns are no longer the sole concern of the military, but rather extend across the electronics industry and around the world. We often divide these into two broad categories:

- *Commercial/industrial/telecomm/medical* , Most digital electronics in these areas are now subject to RE requirements, often well into the GHz range. The limits are based on protecting television receivers, typically located 3-10 meters from the source.

- *Military/avionic/vehicular,* Virtually all electronics are subject to RE requirements, often well into the multi-Ghz range. These limits are much more stringent, typically based on sensitive radio receivers, located as close as 1 meter away.

A KGB Bullet...

Here are some conversion factors for sinusoidal waveforms (just in case you have forgotten)

-Peak to RMS - 0.707	-RMS to Peak - 1.414
-Peak to Average - 0.6366	-Average to Peak - 1.5708
-RMS to Average - 0.90	-Average to RMS - 1.11

(From QST Magazine, December 2010)

Designing for the second category can be much more challenging. Depending on the specifications, it is not unusual for military specs to be 30 dB or more stringent than commercial specs. The avionics and vehicular specs can be even tougher, particularly in frequency ranges critical to radio communications or navigation.

This can pose a problem for designers moving from one industry to another, or incorporating new technology. We've seen good commercial designers become very frustrated when moving to the military/vehicular/avionic areas. And we've seen both groups become frustrated when they incorporate sensitive onboard radio receivers.

Design drivers... Unlike the early days, arcing and sparking are no longer the primary causes of RE. Yes, they still deserve attention, but the primary causes today are highly repetitive digital signals, such as clocks and other similar signals (controls, bus activity, etc.) We're fond of saying that 95% of your RE problems are probably due to the 5% of these critical circuits. (No 80/20 here.)

Both *clock rates* and *edge rates* contribute to these emissions. Doubling *clock rates* can easily double the RE levels, and increasing *edge rates* can have an even larger impact. Unfortunately for electronics designers (but perhaps fortunately for those of us in the EMI business), both trends continue to increase in speed.

The edge rates can be particularly vexing, as semiconductor "shrinks" often greatly increase edge rate speeds. Thus, even if you use the same devices and the same design approaches, you can still get burned by increasing RE levels. We've seen this happen many times over the years.

In addition to clock and edge rates, two other factors are *proliferation and proximity.* Modern electronics often include multiple clocks on multiple boards in multiple systems. With onboard receivers (wi-fi, cellular, GPS), these are often located much closer than the 1-10 meter distances assumed by current RE requirements. The net result -- a whole new class of RE problems to deal with.

Some RE solutions... By now, it should be apparent that a past RE design approaches may not longer suffice. Let's divide the problem into three categories:

(1) Commercial/industiral/telecomm/medical - no embedded radio receivers - least stringent. Primary sources are clock harmonics.

Typical solutions - Pay attention to the clocks on the circuit boards (rise time control and power decoupling.)

Spread spectrum clocking is very popular, and often provides an easy 6-10 dB of emissions reductions. May need high frequency filters on power and I/O lines. May need moderate shielding on cables and cabinets.

(2) Military/avionic/vehicular - no embedded radio receivers - more stringent, typically by 20-30 dB. Can be

more severe in select cases. Primary sources are clock harmonics, repetitive controls signals, and busses.

Typical solutions - Pay attention to clocks and the "divided" clock circuits (controls, busses, etc.) Probably need high frequency filters on power and I/O lines. Better shielding on cables and cabinets. Commercial assemblies (displays) and Ethernet cables usually need shielding, as these are designed only to meet commercial standards.

(3) Embedded radio receivers - As soon as you add an embedded receiver, you may need to reduce emissions by 60 dB or more below nominal commercial levels (or 30 dB below nominal military levels.) GPS receivers are particularly critical (see the KGB for Summer 2009.)

Any digital signal can contribute to these problems. Also, with no specific regulations today, testing may mean assuring any radio receivers have adequate sensitivity.

Typical solutions - At these levels, nothing is typical anymore. Pay extreme attention to clock, of course, and the subdivided clocks. Since the antennas for the embedded receivers are often on or near the circuit board, pay attention to both antenna location and routing of internal cables. Internal shields may also be needed.

Also, you may need to consider advanced techniques such frequency management (avoid harmonics landing on receiver frequencies such as GPS), DSP, and special clock modulation techniques. See our current book review for more details on the latter.

Of course, none of these negate the standard EMI design techniques you already use. But with new technologies come new threats. As such, new design techniques and approaches may be needed.

We hope you enjoyed our RE tutorial. Regardless of your EMI concerns, call us if you need help.

You Might Be an Engineer If...

-You find the burnt out bulb in the Christmas tree lights.

-Your wrist watch has more power than a 2 GHz Pentium.

-You tell your wife her straight hair is nice and parallel.

-Your questions stump the salespeople at Circuit City.

-You have Dilbert comics displayed in your work space.

-You receive all your jokes through e-mail.

(From an e-mail, of course.)

In Memory...

We regret to report the passing of John Howard, 70, a long time friend and EMC colleague. Tragically, John died in a plane crash in Colorado in August 2010. John, a glass of wine will be hoisted to you *(a long running joke between John and Daryl.)*

Book Review...

Platform Interference in Wireless Systems, by Kevin Slattery and Harry Skinner. This books discusses the special EMI problems that can occur when one embeds sensitive radio receivers (wi-fi, cellular phone, GPS) in "noisy" digital systems. Lots of practical stuff -- or as the authors state, "models, measurement, and mitigation."

Kevin Slattery (Intel Labs) spoke on this topic our both of our IEEE EMC Society Chapters (MN and AZ). These problems are increasing rapidly -- if you haven't seen them yet, you will. We certainly have. Newnes, 2008.
ISBN 978-0-7506-8757-7. $84 at amazon.com.

-- Life isn't about how to survive the storm,
but rather how to dance in the rain.
-- Author Unknown

Three Key Answers to EMI Questions...

Well, it depends ... on frequency, signal amplitude, rise time, impedance, dimensions, etc.

This is the "workhorse" answer and is used most of the time. It is particularly helpful when you need to buy some time to think about the issues.

Yes... you really do need all those parts.
No... you can't take any of those parts out.

The last two answers are useful when management presses you for a "yes/no" answer.
(Thanks to Scott Roleson, PE.)

Kimmel Gerke Webinars...

We are finally about to launch our webinar program. The goal is to offer some focused topics that we don't cover in depth our public EMC seminars. We initially plan to offer these at two levels:

-- Basic - For those seeking introductory EMI information. These will draw on our existing materials for IEEE talks, past tutorials, etc. These will be free.

-- Advanced - For those seeking information beyond our EMI classes. Since these involve new material preparation and development, these will have a nominal fee.

Here are several topics under consideration:

- -- Design Impact of Various EMI Regulations
- -- EMI Design Guidelines for Cables & Connectors
- -- ESD as an EMI Problem - Causes and Solutions
- -- Design Impact of MIL-STD-461 & MIL-STD-464
- -- EMI in Power Electronics - Design & Systems
- -- Software as an EMI fix.
- -- Design techniques for systems with embedded radios.

Let us know if you have a topic idea, and watch our website, *www.emiguru.com*, for schedules and details. We are looking forward to this "EMC Experiment."

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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 info on our services, both consulting and training.

EDN Designer's Guide to EMC...

Written entirely by Kimmel Gerke Associates. First published in 1994, and updated in 2001 (three new chapters.) Now available -- *at a reduced price* -- directly from Kimmel Gerke Associates.

Order on-line at *www.emiguru.com*, for $29 (includes US shipping.) Call for special pricing on multiple copies. *Attend a class and get a FREE copy of this book.*

In-House EMC Courses...

Our on-site classes are very popular. Here are some examples of dedicated classes we have done for our clients:

-Design for EMC (2 days)
-EMC Grounding & Shielding (2 days)
-EMC in Military Systems (2 ½ days - 3 days)
-EMC in Avionics Systems (2 days)
-EMC in Medical Devices (2 days)
-EMC in Vehicular Electronics (2 days)
-EMC and Signal Integrity in PCBs (1 day)
-EMC for Mechanical Engineers (1 day)

We can customize to meet your special needs. Flat rate for up to 30 students, but with even dozen students, an in-house class makes sense. Call 888-EMI-GURU for more information on an in-house class at your facility.