KIMMEL GERKE Bullets

EMI GURU

Spring/Summer 2004

Welcome to KGB...

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

This KGB discusses EMI in ICs. We first wrote about this topic in 1996, so we are probably overdue for a revisit. Yes, we continue to see IC related problems, both emissions and immunity. In a recent case, an analog isolation circuit was chopping "low frequency" signals at a 1 MHz rate — which resulted in harmonics every 1 MHz, causing radiated emissions test failures. That was a sneaky one, since at first everyone thought the harmonics were from a switching mode power supply.

Fortunately, IC designers are becoming more sensitive to EMI issues. Unfortunately, they can't solve all the EMI problems at the IC level — we still need to follow good EMI design practices at the board and system levels.

As always, give us a call if we can help you out with any of your EMI problems - from micro-chips to mega-systems.

Best Regards— Bill Kimmel, PE, & Daryl Gerke, PE

Please Requalify...

It is that time of year again, when we ask you to requalify for KGB. You can do so on line at *www.emiguru.com/register.html*, or you can send in the enclosed card if you received this by snail mail. (Not necessary if you have signed up recently, or attended a seminar in the past year.)

Please include your E-MAIL address, plus your current SNAIL-MAIL address. Since many company firewalls block outside messages, your HOME e-mail is a good idea. Your HOME snail-mail address is OK too.

Well over half of our subscribers now receive the electronic version of the KGB. We thank you... it saves us money on postage and printing, and it lets you store them or forward them to your friends and colleagues. Thus, e-mail will be the preferred medium.

Our Privacy Policy— Our list is PRIVATE... and we NEVER share your name, address or e-mail with anyone! In addition to KGB notices, we do let you know when we are holding a class in your vicinity.

Shows and Conferences...

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

– IEEE Symposium on EMC... August 9-13, 2004, at the Santa Clara Convention Center, Santa Clara, CA, USA. Hope to see you there...

Public EMC Courses...

Here are the cities we have tentatively selected for the Fall 2004 EMC seminar series sponsored by Tektronix and Kimmel Gerke Associates, Ltd. For more information, please visit our website, *www.emiguru.com*.

- **Denver, CO - September 2004**
- **Seattle, WA - September 2004**
- **Chicago, IL - September 2004**
- **Minneapolis, MN - October 2004**
- **Detroit, MI - October 2004**
- **San Jose, CA - October 2004**
- **Los Angeles, CA - November 2004**
- **Phoenix, AZ - November 2004**

By the way, four or more from the same company qualify for a discount. All classes are conducted by either Bill or Daryl.

In-House EMC Courses...

Our on-site classes are also popular. Here are some recent classes we have done for clients:

- **Design for EMC (2 days)**
- **Design & Troubleshooting EMC (2 days)**
- **Design, Systems, & Troubleshooting (3 days)**
- **Medical Design for EMC (2 days)**
- **EMC in Telecommunications (2 days)**
- **EMC in Vehicular Electronics (2 days)**
- **EMC in Military Systems (2 ½ days)**
- **EMC in Avionics Systems (2 days)**
- **Design for ESD (1 day)**
- **EMC in Systems (1 day)**
- **EMC Grounding & Shielding (2 days))**
- **EMC and Signal Integrity in PCBs (1 day)**

We can customize to meet your special needs. You supply the meeting space – we supply the materials and the instructor (either Bill or Daryl). *Flat rate for up to 30 students, but with even a dozen students, an in-house class often makes sense.*

Kimmel Gerke Bullets is a free newsletter on Electromagnetic Interference/Compatibility (EMI/EMC).
Published by Kimmel Gerke Associates, Ltd., 300 Christine Lane, W. St. Paul, MN 55118 • 1-888-EMI-GURU • http://www.emiguru.com

Focus on EMI and Integrated Circuits...

Since we first discussed EMI and ICs eight years ago, the problems have continued to grow. Since then, we have had the opportunity to work both "outside the chip" and "inside the chip" on these issues. The physics are the same; it is usually just a matter of size and scale.

Since most of our clients design at the board or system level, we will focus here on solutions that work "outside the chip" at the board level. Keep in mind that while IC designers often work very hard to improve things by a factor of two (6 dB), we can easily degrade things by a factor of ten (20 dB) at the board level with poor EMC design techniques.

Digital emissions - Since most digital electronics use clocks, and since clocks are repetitive, they are rich sources of harmonic energy. As a rule of thumb, the first twenty harmonics are potential troublemakers, although we've seen higher level harmonics create problems as well. Thus, even a "slow" embedded controller with a 20 MHz clock can easily cause problems in the hundreds of MHz. A higher speed device operating in the GHz range has harmonics well into the tens of GHz. One observation — clocks above 1 GHz usually are not as "square" as low frequency clocks, so the harmonic content is not as bad.

The digital emissions are compounded by increased edge rates. For example, most EMC engineers consider a 1 nsec edge rate to be "equivalent" to about 300 MHz, which is often slow by today's IC standards. At 100 psec, that equivalent frequency is now 3 GHz, clearly in the microwave range.

These faster edge rates can also lead to signal integrity problems, due to power spikes, ground bounce, and crosstalk. Increased signal integrity problems often also mean increased digital emissions problems.

The solutions include high frequency power decoupling, careful clock routing, and even filtering of critical traces. Incidentally, many IC manufacturers now add small amounts of decoupling and filtering right on the silicon, which was something we only speculated about eight years ago. How quickly things change and become reality!

Parasitic emissions - These are unexpected high frequency emissions from supposedly "low frequency" parts. We've seen a drastic increase in these problems in the last eight years. The major offenders are power regulators (feedback devices) and amplifiers (op amps, audio circuits, etc.)

These problems often manifest themselves in the 200-500 MHz range. Two important clues are that these emissions are not harmonically related to any clock, and may drift or differ among units under test.

The solutions are to include high frequency decoupling capacitors (typically 1,000 - 10,000 pF ceramic devices) in addition to any lower frequency power decoupling capacitors. Ferrite beads can also be very helpful, in both power and signal leads, since they are lossy in the 100-1000 MHz range.

We recently saw a new wrinkle with a "low frequency" isolation component that used an internal 1 MHz clock to modulate/demodulate analog signals to cross a capacitive isolation barrier. Unfortunately, the 1 MHz harmonics were all over the place, necessitating both power and signal filtering to tame the problems. The solution here is to pay attention to how IC devices actually operate.

A general moral is that even "low frequency" ICs can cause "high frequency" problems.

Radio Frequency (RF) Susceptibility - We have also seen a corresponding increase in problems with "low frequency" devices being vulnerable to "high frequency" RF energy in recent years. Once again, the major offenders are low level analog circuits (op amps, instrumentation amps, even simple audio amps) as well as power regulators (and other power circuits.)

These problems can manifest themselves throughout the RF range, from kHz to GHz. Often times, the digital section works fine, while the analog section is trashed by RF energy. Generally, the lower the signal level, the more vulnerable the circuit. Thus, low level audio input or instrumentation stages are particularly troublesome.

Common solutions are high frequency power decoupling and filtering. The usual components are high frequency ceramic capacitors and ferrite beads, or integrated "T-filters." We have had good luck in this area with the new X2Y® devices, which incorporate microwave techniques to significantly extend their frequency range.

Fast Transients - Many electronic systems today are upset by two types of "fast" transients — ESD (Electrostatic Discharge) and EFT (Electrical Fast Transient.) The former is usually the result of triboeletrcic charging due to motion (human or otherwise), and the latter is usually due to arcing at power contacts or switches. Both result in edge rates in the 1-5 nsec range, well above today's normal logic edge rates.

These problems often manifest themselves as unwanted resets or interrupts. Secondary effect includes memory corruption (corrupt read/write lines) or change of machine state (corrupt registers) or other control logic.

Common solutions include high frequency filtering (ferrites and/or 1000 pF capacitors) of critical lines (resets, interrupts, control lines, etc.). This is often augmented with high frequency transient protection at I/O ports. The transient

A KGB Bullet...

Here ia a great "rule of thumb" we saw in the January 2004 issue of *PCB Design and Manufacture* —

"As a rough estimate, the rise time degradation in a typical FR-4 interconnect is about 10 ps per inch of interconnect (due to losses.)

Thus, signals with a bit rate over 1 Gbps, or bit period shorter than 1 nsec, and transported over lengths longer than 20 inches, are subject to lossy line effects."

— Dr. Eric Bogatin

protectors must be able to respond to nsec edge rates, which means using silicon devices or surface mount MOVs. While suitable for slower transients, arc devices are usually too slow for ESD/EFT.

We hope this update has been helpful, and we wonder what changes the next 8-10 years will bring. In the meantime, please give us a call if we can help you with today's or tomorrow's EMI problems.

> Why is it a slight tax increase costs you two hundred dollars, and a substantial tax cut saves you thirty cents?
>
> — *Author Unknown*

Some Engineering Humor...

Just in case you are job-hunting for a new engineering position, here are some suggested answers for those tough job interview questions (sent to us by a friend via e-mail...)

Question: Why did you leave your last job?
Real Answer: It stunk.
Suggestion: I felt my talents were underutilized.

Question: How do you get along with others?
Real Answer: I hate people.
Suggestion: I think the interpersonal dynamics of the work place can be among the most satisfying aspect of any job.

Question: How do you get along with your current boss?
Real Answer: Fine, considering what a jerk he is.
Suggestion: I don't think I would call him a boss; he has been more of a mentor to me.

Question: Do you ever get angry with you coworkers?
Real Answer: I don't get mad, I get even.
Suggestion: Nothing angers me more than to see a coworker not pulling his/her weight or goofing off. Yes, sometimes I get angry with my coworkers.

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**

*EMI-GURU® and EMI-Toolkit® are registered trademarks of Kimmel Gerke Associates, LTD.

Book Review...

EMI Troubleshooting Techniques, by a respected EMI author and long time friend, Michel Mardiguian. Many practical methods and fixes to a wide range of EMI problems. ISBN 0-07-134418-7. McGraw Hill, 2000.

SPAM Alert...

As a result of over 100 SPAMS per day (for each of us), we are now using SPAM filters on our incoming e-mail. As you know, they are not perfect, so we sometimes lose good messages. And even though we quickly check the filtered messages, we still may miss one.

Thus, if you send us an e-mail and do not get a reply within several days, please RESEND the e-mail AND then ALSO leave a PHONE MESSAGE (toll free) at 1-888-EMI-GURU. (Also, consider adding your HOME e-mail for an extra reply address - YOUR company filters and firewalls may be blocking OUR replies.)

A Beginner's EMC Library...

Students in our classes often ask for recommendations on introductory EMC books. Here are several of our favorites, depending on experience and interest :

Novice — If you are brand new to EMC, we usually recommend the *EDN Magazine Designer's Guide to EMC*, (Cahners - 2001) and written by us (Kimmel & Gerke). Easy to read, with no equations or math. (Go to our web site, *www.emiguru.com*, and click on the book icon.)

Intermediate — If you are ready for a bit more detail, we like *Noise Reduction Techniques in Electronic Systems*, written by Henry Ott (Wiley-1988.) An easy read, this is an EMC classic with plenty of technical detail.

Advanced — For in-depth details, we like *Introduction to Electromagnetic Compatibility*, by Dr. Clayton Paul (Wiley - 1992.) Often used as a college text at the senior/graduate level, it is well written and includes all the relevant math and equations.

Circuit Boards — If you are only interested in printed circuit boards, we have two favorites: *High Speed Digital Design*, by Dr. Howard Johnson, (Prentice Hall - 1993) and *Printed Circuit Design for EMC Compliance*, by Mark Montrose (IEEE Press - 2000.) The first provides a strong signal integrity perspective and the second provides a strong EMC perspective.

For a more detailed list of recommendations, see the EMI bibliography on our web site at *www.emiguru.com*.

Application Note...

Although we first posted this notice some time ago, we still get requests for a copy of the Intel Application Note (*AP711-EMI Design Techniques for Microcontrollers in Automotive Applications)* that we helped write some years back, now out of print. We have a PDF version, so if you need a copy, e-mail Daryl at *dgerke@emiguru.com.*

About Kimmel Gerke Associates...

We are often asked to give a quick description of what we do and who we are. If you are asked by someone needing EMI help, here are several key points about KGA...

Point I... We are a two-man **electrical engineering firm that specializes in consulting & training on EMI/EMC (electromagnetic interference and compatibility) issues.** These include five key areas:

- **Regulatory Compliance** (Emissions, immunity, FCC, CISPR, IEC, CE, MIL-STD-461, DO-160, SAE, etc.)
- **Radio Frequency Interference** - (RFI)
- **Electrostatic Discharge** -(ESD)
- **Power Disturbances** - (Transients, magnetic fields, etc.)
- **Self Compatibility** - (Signal Integrity, Analog, etc.)

Point II... We are Registered Professional Engineers (PE) and NARTE Certified EMC and ESD engineers. **Between us, we have over 75 years of industry experience.**

Point III... We are not a test lab - **our emphasis is on EMC design, troubleshooting, and training.** While we are knowledgeable on key EMC tests and regulations, our focus is on design/systems issues, and **how to identify, prevent, and fix EMI problems.**

Point IV... We serve many industries, and **our support ranges from circuit boards to complete systems.**

These include the following:

- **Military/Aero** (MIL-STD-461, TEMPEST, EMP, etc.)
- **Avionics** (DO-160, MIL-STD-461, etc.)
- **Computers** (FCC, EU, PCs to supercomputers)
- **Industrial Controls** (Individual controls to full systems)
- **Vehicular** (SAE, automobiles, farm machinery, etc.)
- **Medical** (FDA, diagnostic, clinical, patient connected)
- **Telecommunications** (BELLCORE 1089, etc.)
- **Facilities** (Shielded rooms, lightning, power)
- **Site Surveys** (RF, magnetic fields, mitigation help)

Point V... We are an independent consulting firm with no outside affiliations. **Our advice and recommendations are free from any bias or other business concerns.**

Kimmel Gerke Associates, Ltd.
300 Christine Lane
W. St. Paul, MN 55118

1-888-EMI-GURU

FIRST CLASS MAIL