KIMMEL GERKE Bullets

Spring , 1999

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 discusses signal integrity and EMC. While both often use similar techniques, there are important differences in the two disciplines. We'll compare and contrast these differences, and offer some suggestions.

One key difference is amplitude. Signal integrity is usually dealing with millivolts and milliamps, while EMI issues may be dealing with vastly different amplitudes (microvolts and microamps for emissions, and volts or amps for immunity.) Thus, standard signal integrity techniques may not be sufficient for EMI issues.

Another difference is scope. Signal integrity usually deals with circuit boards, while EMI may deal with boards, cables, connectors, grounding, filtering, and more. Nevertheless, good signal integrity design is a critical element of good EMI design, particularly for high speed systems.

As always, give us a call if we can help you with any of your EMI problems - from circuit boards to full systems and facilities. (Or as a paper we presented many years ago said, "*EMI - from Microchips to Megamalls...*")

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

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.

Arizona EMC '99... May 3, 1999, at the Doubletree La Posada in Scottsdale, AZ. This one day colloquium is sponsored by the IEEE EMC Society, and features several well known EMC speakers. The keynote speaker is Henry Ott, author of "Noise Reduction Techniques in Electronic Systems." Both Daryl and Bill will also be speaking.

IEEE International EMC Symposium... August 2-6, 1999, at the Washington State Trade & Convention Center in Seattle, WA. We'll both be there, of course. Daryl will be presenting "Diagnosing & Troubleshooting EMI Problems - Tips & Techniques" during the Monday tutorial workshops. Be sure to stop by at our booth (#204).

Fourteenth Annual Minnesota EMC Event... Moved back to the fall for 1999. Combined day of training and exhibitions. Hard to believe we've been involved with this show for 14 years.

Area Code Changes... Thanks to the "wireless explosion", both Bill and Daryl have new area codes. Here are our new direct numbers:

—Bill Kimmel - 651-457-3715 (Was 612)

—Daryl Gerke - 480-755-0080 (Was 602)

Of course, you can always reach us through our ***Toll Free "888" number - 1-888-EMI-GURU.*** This reaches our answering service in Minnesota, so please leave a message and we'll get back to you. For calls from outside the US, please use 612-330-3728.

You can also contact us at the following: **E-Mail..**A preferred way of reaching us if you don't need a "real-time" answer. We both check our mail boxes regularly, and it works out well.

Addresses are: Bill Kimmel - bkimmel@emiguru.com
Daryl Gerke - dgerke@emiguru.com

World Wide Web —
Visit our "home page" at **http://www.emiguru.com.** You'll find back issues of the KGB (Kimmel Gerke Bullets), plus other information.

Reprints... EDN Magazine's *Designer's Guide to Electromagnetic Compatibility...*

This popular EMC design guide (written entirely by us) is still available. For your copy, call Cahners Reprint Services at 1-800-523-9654. Only $19.95+ shipping.

Kimmel Gerke Bullets is a newsletter on electromagnetic interference/Compatibility (EMI/EMC).
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"Joint" On-site EMC Classes...

Interested in having an "in-house" class on EMC, but don't have enough people to justify it. Then consider a "joint" class with another local company. We have done several of these with good success. The first one we did was for a client in a smaller

"non-electronic" city. They even formed a consortium with several other firms, and have hosted several technical seminars, including ours.

Here are several popular classes, and we can mix & match:

-Design for EMC (2 days)
-Systems EMC/Grounding & Shielding (2 days)
-Medical Design for EMC (2 days)
-EMC Troubleshooting (1/2 to 1 day)
-Understanding EMC Regulations (1 day)

Call 1-888-EMI-GURU for more information.

EMI Suppression Handbook...

by Bill Kimmel and Daryl Gerke, and edited by our good friend and Associate, Dr. Tom Chesworth. This is a collection of articles written over the past ten years for *Electromagnetic News Report.* The book includes numerous "war stories" on various aspects of EMC — most with a lesson or moral.

Only $20 plus shipping. To order, contact Seven Mountains Scientific at 814-466-6559, or visit their web site at *www.7ms.com.*

Focus on Signal Integrity...

As digital circuit speeds increase, so has the interest in "signal integrity" (SI). As EMC engineers, we've been dealing with these problems for years, under the guise of "self compatibility." We sometimes hate to admit this, but we first saw those problems in the 1960s, 70s and 80s as engineers at Unisys & Control Data (with mainframe computers) and MCT (high speed semiconductor testers.) Now, thanks to today's high speed electronics, the problems are a lot more common and widespread.

We often view SI as a special case of EMC. There are, however, some key differences between the two disciplines. Fortunately, many of the same solutions apply to both. In this issue, we'll compare and contrast those differences, looking at objectives, scope, signal levels, concerns, and of course, some solutions.

Objectives - The primary objective of SI is "clean signals", to assure proper and satisfactory operation. The primary objective of EMC is usually to pass EMC tests, with satisfactory operation a secondary (albeit extremely important) objective. One might even argue that SI trumps EMC, since if the system doesn't work as intended, it doesn't matter if it passes EMC tests.

Scope - As a result of these differences, SI tends to have an "internal" view, while EMC has a broader view. SI usually focuses on high speed digital circuits on printed circuit board (and perhaps connectors), since this is where the high speed signals live.

EMC, on the other hand, deals with the entire system — circuit boards, enclosures (shielding), power supplies (filtering & transient protection), cables & interconnects, and grounding. EMC may also include low level analog circuits, as well as medium and low speed digital circuits.

Signal Levels - This is a key difference between SI and EMC. SI usually is dealing with millivolts & milliamps - signals large enough to cause circuit upsets. EMC varies, depending on whether the problems are due to emissions or immunity.

For emissions, EMC levels are often in the microvolt or microamp range, or several orders of magnitude below "normal" SI levels. (Remember, even a few microamps of common mode current on a cable at 100 MHz can cause you to fail FCC or CE emissions tests.) As a result, SI design techniques alone may not be enough.

For immunity, EMC levels may start out in the kilovolt or kiloamp range (such as lightning and ESD), with resulting voltages/currents at the circuit levels well above "normal" SI levels. For EMC, both damage and upset are concerns. Thus, additional high level protection is often needed.

Key Concerns - For SI, there are four major concerns: *reflections, crosstalk, ground bounce, and power decoupling*. Transmission line analysis techniques are often necessary for SI, since at high speeds the circuit effects are distributed, rather than constant. This is all due to the "speed of light" and wavelengths. (Ed. Note - if the speed of light were infinite, we wouldn't have SI problems. We wouldn't have EMC problems, either, but our universe probably wouldn't work anyway.)

For EMC, there are three major concerns: *emissions, immunity, and "self compatibility".* The latter may include analog/digital jamming, transients due to relays or motors, as well as high speed SI effects. Both transmission line and antenna analysis techniques are often necessary for understanding EMC effects. Furthermore, EMC is often about "DC to daylight", not just about high speeds.

Solutions - All this brings us to a discussion about preventing and solving both SI and EMC problems. Fortunately, good SI design is compatible with good

EMC design, and is often critical to EMC success, particularly for high speed digital systems.

Good SI/EMC design begins with the circuits and circuit boards. Common techniques include attention to critical circuits, careful circuit layout, use of multi-layer boards, attention to power decoupling, and control of reflections and crosstalk on electrically "long" traces. Additional EMC solutions include grounding, shielding, filters, and transient protection.

Critical circuits for SI and EMC are often the same. Special attention must be given to clocks (and other highly repetitive signals) to minimize harmonics for EMC, and to assure clean signals for SI. In addition, special attention should be given to interrupts, resets, and key control lines (read/write, strobes, ALE, etc.) to assure they will not be upset by internal (SI) or external (EMC) sources.

During design reviews, we usually recommend additional high frequency protection for both analog circuits and power regulators. These last two cases are not SI related, but they can still be very important for overall EMC immunity.

Multi-layer circuit boards are very beneficial for both SI and EMC. There mere presence of power/ground planes can often reduce EMC effects (both emissions and immunity) by 20 to 40 dB (10-100 times better.) These same effects often help reduce crosstalk and ground bounce effects by similar amounts. Don't overlook multi-layer boards for non-SI cases, such as sensitive analog circuits. The multi-layer approach here can also reduce RF immunity effects by 20 dB or more as well.

Power decoupling is also crucial for both SI and EMC. The objectives are slightly different, though. For SI, the goal is to minimize "droop" under switching conditions, which establishes a minimum amount of capacitance or local energy storage. For EMC, the goal is to minimize high frequency harmonics and their associates "loop sizes". As a result, the capacitor location becomes very critical for EMC. We've seen cases where SI was fine, but EMC was not, due to power decoupling issues.

Impedance control and the corresponding control of reflections is very important for SI and EMC. For SI, this helps assure clean signals. For EMC, it minimizes radiation, since any impedance discontinuity represents a chance for energy to radiate to/from the corresponding traces. In effect, the transmission lines start to act as unwanted "antennae."

Crosstalk control is also very important for both SI and EMC. For SI, once again this helps assure clean signals. For EMC, crosstalk often represents a very important "sneak path", particularly for emissions. We've seen many cases where crosstalk was a key EMC culprit.

Grounding, filtering, shielding, and transient protection are usually more important to EMC than SI, since they interface with the outside world. These provide primary barriers (both conducted and radiated) against outside threats, and are often the "last chance" to stop emissions. As such, these are very critical EMC tools.

In summary... We hope this quick overview has provided given some insights and appreciation on "signal integrity vs. EMC." They actually complement each other, and good SI design is a very important first step towards good EMC design. We encourage you to consider both concepts in your designs.

E-mail Version of KGB...

Would you like to receive the KGB by E-mail instead of "snail mail?" That would eliminate any problems with the "mail room" or address changes. (Sadly, at each issue we must drop quite a few names as KGBs are returned "address unknown.") It would also make it easy to forward the KGB to other interested colleagues.

If you prefer an E-mail version, please check the "E-mail Option" on the enclosed reply card. Thank you.

Book Review...

Since we've focused on signal integrity, here is a new book on the topic that we found to be quite good.

Signal and Power Integrity in Power Systems (TTL, CMOS, and BiCMOS)...by James Buchanan, published by McGraw Hill, 1995. (ISBN 0-07-008734-2). A detailed treatment of the subject that is a pleasure to read. The emphasis is on high performance digital components. A nice compliment to Howard Johnson's excellent text on signal integrity (*High Speed Digital Design*, reviewed in the Fall 1993 *KGB*.)

SOME KGB BULLETS...

Here are some more EMC "info-bullets" on the Internet:

www.ball.com/aerospace/ieee_emc.html — Information on the 1998 IEEE EMC Symposium in Denver.

www.umr.emclab.edu/ — University of Missouri at Rolla - Lots of good info on EMC vendors, books, and more.

www.sigcon.com/ — Dr. Howard Johnson, author of "High Speed Digital Design". Good signal integrity info.

www.emiguru.com — Our site. Good info, or course.

Some Humor...

Two issues back we printed a list of 10 "engineering terms" and their translations ... here are 10 more...

1. EXTENSIVE REPORT IS BEING PREPARED ON A FRESH APPROACH (We just hired three guys... We'll let them kick it around for a while.)

2. WE WILL LOOK INTO IT (By the time the wheel makes a full turn, we assume you will have forgotten.)

3. GIVE US THE BENEFIT OF YOUR THINKING (We'll listen to what you have to say, as long as it doesn't interfere with what we have already done.)

4. GIVE US YOUR INTERPRETATION (Your warped opinion will be pitted against your adversary's good sense.)

5. SEE ME or LET'S DISCUSS (Come down to my office, I'm lonely.)

6. RUGGED (Too heavy to lift.)

7. LIGHTWEIGHT (Lighter than rugged.)

8. YEARS OF DEVELOPMENT (We finally got one that worked.)

9. ENERGY SAVING (When the power switch is "off.")

10. THE ENTIRE CONCEPT WILL HAVE TO BE ABANDONED (The only guy who understood it quit.)

Public Seminars Now on Web Site...

You can now see the schedule for *"EMI Made Simple - High Performance Design"* (sponsored by Tektronix) for several months in advance. As a KGB reader, you already are notified about local seminars. Now you can see others, and perhaps plan trip around one. Don't forget our "Winter Getaways" in Jan/Feb. (Visit *www.emiguru.com*.)

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