

KIMMEL GERKE



Bullets



Fall, 1996

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 EMI in integrated circuits. In the past, EMI problems were primarily systems and printed circuit board problems. As IC speeds increase and IC designs shrink, however, we are beginning to see classical EMI and signal integrity problems right at the chip level. These problems include on-chip crosstalk, ground bounce, and even direct radiation from the chips themselves.

Fortunately, IC designers are becoming sensitive to these problems. Unfortunately, they still can't solve all the EMI problems at the IC level. We'll take a quick look at these emerging problems, and how they can affect your designs and systems.

As always, give us a call if we can help you out with any of your EMI problems — from IC's to systems.

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

1997 EMI Winter Getaway

Need a winter break, with some fun in the sun? Want to learn more about EMI design and troubleshooting? Then join us in **Orlando or San Diego in February** for our expanded three day EMI seminar, sponsored by Tektronix. In addition to two days on design, we'll host an optional third day on EMI troubleshooting, complete with case studies.

Although we only do this once a year, the troubleshooting workshop has proved very popular. It's optional, but you must take the seminar to attend the workshop. (If you have already taken our seminar, call for special arrangements.) Fee is \$795 for two days, or \$1095 for all three days. For more details, see the insert or call us at 1-888-EMI-GURU.

Shows and Conferences...

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

Medical Design & Manufacturing West 97

Conference... February 11-13, 1997, at the Anaheim Convention Center in Anaheim, California, and sponsored by *Medical Devices and Diagnostics Industry* magazine. Bill is chairing a session on EMC in medical devices and systems, always a popular subject at this international conference.

Medical Design & Manufacturing Regional 97

Conference & Exposition... March 24-26, 1997, at the Orlando Expo Centre in Orlando, FL, and sponsored by *Medical Devices and Diagnostics Industry* magazine. Daryl is chairing a session on EMI in medical devices, which is a repeat of the EMI session in Minneapolis in October. If you missed Minneapolis, here is chance to catch what you missed.

Portable by Design... March 24-27, 1997, at the Santa Clara Convention Center in Santa Clara, CA, and sponsored by *Electronic Design* magazine. Bill will be presenting an all day tutorial on EMC design for portable electronic devices.

Twelfth Annual Minnesota EMC Event... April 22-23, 1997, at the Thunderbird Hotel in Bloomington, MN. One day exposition, and one day of seminars. Remember the EMC EVENT has moved to the spring.

IEEE EMC Symposium... August 18-22, 1997, at the Austin Convention Center in Austin, TX. Hope to see many of you there, enjoying some of that famous Texas hospitality. Y'all come now, hear?

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

We're told this EMC design guide (written entirely by us) is still a popular item. For your copy, call Cahners Reprint Services at 1-800-523-9654. Only \$19.95+ shipping.



Focus on EMI and Integrated Circuits...

A recent article in *EE Times* stated that "IC designers are (now) facing signal integrity issues that have been commonplace for designers of printed circuit boards..." The article went on to describe problems with power droop, ground bounce, on-chip crosstalk, and emphasized the need for good signal integrity design at the IC (integrated circuit) level.

As EMI engineers, we recognize that "signal integrity" issues and EMI issues are similar and even identical in some cases. A key difference is that while "signal integrity" often means millivolt/milliamp perturbations, EMI problems (such as radiated emissions) are often due to *microvolt/microamp* perturbations. The root cause is often the same, but the levels are much lower.

We've recently run into several IC/EMI problems. We've seen some surprising emissions due to IC crosstalk, as well as spurious radiation due to parasitic oscillations. We've also been forced to add or improve decoupling, filtering and shielding right at the IC. In this KGB, we'll take a quick look at several of these "interesting" EMI issues at the IC level.

Power Spikes - As ICs become faster and faster, their need for electrons (current) during switching becomes faster, too. These "fast" electrons are usually supplied by a nearby decoupling capacitor. These capacitors are often limited by inductance, resulting in voltage sags during switching, due to $L di/dt$.

If the sag is large enough, it's a signal integrity problem. But even small sags can cause radiated emissions problems, as high frequency currents are drawn from larger "loop areas". In fact, poor power decoupling at high frequencies (high clock rates with fast transitions) is a major contributor to radiated emissions problems.

The best solution would be to put decoupling capacitors right on the IC. Maybe it will happen someday, but in the meantime, good high frequency power decoupling is mandatory for high speed systems. In some cases, ferrites are used to provide additional isolation of the IC power feeds. Ferrites don't help with the "large sag" problem (which needs more local energy storage), but they do help with emissions by reducing "loop areas" at high frequencies.

Ground Bounce - This problem is related to the power spike problem, and is also affected by $L di/dt$ issues. There are some key differences from power issues, too.

Large shifts (macro ground bounce) can result in false switching, obviously a serious integrity problem. But even small shifts (micro ground bounce) can cause EMI

problems as slow (and supposedly harmless) signal lines are modulated by higher speed signals sharing the same IC ground. In the latter case, this system works fine, but can still fail EMI tests.

The solution to "micro ground bounce" problems is to assume that any signal line can carry energy at the highest frequency seen in the IC. This often means adding high frequency filters to "slow" I/O lines on a microprocessor, especially those going off the board. Another sneak path for this problem is clock buffers — for example, any time a clock is passed through an inverter, one must assume that all other inverters in this same package are now "modulated" by the clock.

IC Crosstalk - In the past, most of us in the EMI world have assumed that crosstalk at the chip level was insignificant, since the dimensions were too small for typical frequencies and rise times. As such, crosstalk was seen primarily as a circuit board and cable issue.

Unfortunately, due to increased speeds, this is no longer a valid assumption. In fact, we've seen several "IC crosstalk" problems in recent times. (See our recent article in *Electromagnetic News Report* titled *Crosstalk in the Chip* - Nov/Dec 1996. For more info on ENR, call Dr. Tom Chesworth at 814-466-6559).

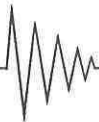
One solution to IC crosstalk is additional high frequency filtering of signal lines on pins adjacent to high speed clock outputs. We've found that usually it's the adjacent lines that cause problems, but we like to probe other IC lines just to be sure. We do this with a voltage probe on a spectrum analyzer, and are interested in relative, rather than absolute levels. It's not unusual to see harmonic levels on adjacent pins at the same levels as the clock at 200 MHz and up.

Parasitic Oscillations - This is another problem, like crosstalk, that has been safe to ignore in the past. Years ago, this was a common vacuum tube problem (remember those??) but it has now come back to ICs. We've seen this problem several times in the past

A KGB BULLET...

"DOD-W-83575A is a MIL-SPEC titled *Wiring Harness, Space Vehicle, Design and Testing, General Specification For*. If you read it for its harness design and routing information, it is (also) useful for signal integrity considerations... design, routing, and testing of production harnesses... (and) systems where service calls will be a major nuisance."

-Email from Greg Davis, Kaman Aerospace
(Thanks)



few years. It often occurs in analog circuits, such as video amplifiers or even voltage regulators. The solution, once again, is high frequency decoupling and attention to other high frequency design techniques. Remember, just because you operate at low frequencies, doesn't mean that high frequency problems won't occur. For EMI and signal integrity, you must assume the worst.

We hope this has been helpful, and maybe even stimulated some thinking about signal integrity, EMI, and integrated circuits in your systems and designs.

Power Lines Not A Threat...

So says a recent panel of scientists who evaluated over 500 studies on the health effects of high voltage power lines. The National Research Council committee spent two years issue, and said that they found "no conclusive and consistent evidence" that power line electric or magnetic fields caused any human disease.

We still see problems with CRTs upset by power line magnetic fields. Hopefully, though, no one needs to worry about any adverse health effects.

Do you remember the good old days — when televisions were connected to antennas, and telephones were connected to cables???

Electronic Communications...

Thanks to all this modern electronics stuff we've all been involved with, it's easy to contact us or get more information.

Here are some possibilities:

World Wide Web — If you haven't already done so, you are invited to visit our recently updated "home page" at <http://www.emiguru.com>. You'll find back issues of the *KGB (Kimmel Gerke Bullets)*, plus an assortment of other EMC related information. Please feel free to pass the address along to others who might be interested in EMC issues.

Toll Free "888" Number... If you need our help, please feel free to call us on our toll free number - **1-888-EMI-GURU** (1-888-364-4878). This reaches our answering service in St. Paul, Minnesota, so please leave a message and we'll get back to you. For calls from outside the US or Canada, you should continue to use 612-330-3728.

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@aol.com

Daryl's Move to Arizona...

As many of you know, Daryl and Mary relocated to Mesa, Arizona, in July. No, this wasn't retirement — just part of a plan to trade "snow and cold" for "desert and heat." We also like to think of this as our first "corporate expansion".

Thanks to all of you who called or sent E-Mails. We really appreciated your kind thoughts. After 21 years in the same place in Minnesota, the move took even more effort than anticipated. But we're fairly settled, and looking forward to enjoying a new phase of life.

Since Mary Gerke does the bookkeeping and billing, invoices and payments will be processed through the Arizona office:

Kimmel Gerke Associates, Ltd.
2538 West Monterey Avenue
Mesa, AZ 85202

All other correspondence, should be sent to our corporate headquarters in Minnesota:

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

Address changes should be sent to Sharon Kimmel at the Minnesota office.

Book Review...

We just received a copy of the *AC Power Interference Manual* by Marv Loftness (KB7KK), and we recommend it for anyone dealing with radiated EMI from power lines. Marv is an EMC engineer and former RFI investigator for the Bonneville Power Administration. He has written two previous handbooks on the subject that are well revered in the power industry. This latest book is very well presented, and full of practical ideas and solutions.

Cost is \$24.95 (A good deal.) Published by Percival Publishing, PO Box 4122, Tumwater, WA 98501. The ISBN number is 0-0653760-208.

A KGB Bullet...

Here are some (sometimes) hard to find conversion factors for magnetic fields (assuming $\mu = \mu_0$)

- 1 tesla = 1 weber/sq meter
- 1 tesla = 10^4 gauss
- 1 tesla = 7.96×10^5 ampere turns/meter
- 1 picotesla = 10^{-8} gauss
- 1 picotesla = 0.796 microampere turns/meter

As a rule of thumb, 10 milliGauss upsets a CRT display.



Extra EMC help...

As mentioned in previous KGBs, we made arrangements with two professional colleagues for additional EMC support. Several of you have since had the chance to work with our very capable associates.

Dr. Tom Chesworth, PE, is a "practical PhD" with many years of EMC experience. Tom very proficient in detailed EMC analysis as well. Tom and his wife Jo reside in State College, PA. They also publish *Electromagnetic News Report*, a newsletter on EMC.

Bill Ritenour has 30+ years of industry EMC experience. Bill is also practical and knowledgeable about ESD, EMI, and European EMC Regulations. Bill and his wife Roma reside in Boulder, CO.

We are pleased to have both Tom and Bill helping us and our clients solve EMC problems. Our goal is to continue to provide you with timely EMC support.

Season's Greetings...

Our warm wishes to you and your families this holiday season, and may you have a happy and prosperous 1997... *Bill and Daryl*

EMI-Toolkit® Software ...

We continue to receive orders for our unique EMI software, and we've had good comments from users. Thanks again to all of you who own our software.

EMI-Toolkit® is a collection of over thirty of our favorite EMI formulas, graphs, and tables that we use on a regular basis as EMI consulting engineers. It's like having an EMI reference book (or perhaps even an EMI consultant) at your fingertips.

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