

KIMMEL GERKE



Bullets

Winter 2005

Welcome to KGB...

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

This KGB discusses "Electro Static Discharge," or ESD. Even though we have worked on dozens and dozens of ESD problems over the years, we just realized that we've never dedicated a focus article to this important EMI issue. Incidentally, our most recent ESD troubleshooting consultation took place just last week!

An ESD event can be one of the nastiest transients to deal with. Not only do you need to worry about the direct discharges, but also the "indirect" effects of the transient electromagnetic fields. In this KGB, we'll share some insights based on our ESD experiences.

As always, give us a call if we can help you with any of your EMI problems...ESD, RFI, radiated/conducted emissions, or power disturbance... in the military, avionics, commercial, medical, industrial, telecomm, avionics, automotive industries, and more...

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

Seasons Greetings...

Our sincere best wishes to you and your families this holiday season, and the best to you in 2006... *Daryl & Bill*

EMC Winter Workshops 2006

Orlando, FL - February 6-9, 2006

San Diego, CA - February 13-16, 2006

Need a winter break, and some fun in the sun? Want to learn more about EMC design, systems, or troubleshooting? Then join us in Orlando or San Diego in February for our "once a year" expanded seminar series. (This includes the EMC Troubleshooting, which we offer only at the Winter Workshops.)

Here are the class offerings:

- Two days on EMC Grounding & Shielding
- One day on EMC & Signal Integrity in PCBs
- One day on EMC Troubleshooting.

Take only what you need to get up to speed on EMC.

For more details, visit our web site (www.emiguru.com) or call us toll free at 1-888-EMI-GURU.

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 14-18, 2006, at the Oregon Convention Center, Portland, OR.

-EMC Europe Barcelona... September 4-6, 2006, in Barcelona, Spain.

Public EMC Courses...

Here are the cities selected for the Winter/Spring 2006 EMC seminar series co-hosted by Tektronix and Kimmel Gerke Associates, Ltd. Final dates and locations for sites other than Orlando and San Diego are yet to be determined. For the latest information, please visit www.emiguru.com.

-Orlando, FL - February 6-7-8-9, 2006

-La Quinta Inn Lakeside, Kissimmee, FL

-San Diego, CA - February 13-14-15-16, 2006

-Doubletree Club Hotel Circle, San Diego, CA

-Dallas, TX- March 2006

-Atlanta, GA - March 2006

-Baltimore, MD - April 2006

-Boston, MA - April 2006

-Newark, NJ - May 2006

-Rochester, NY - May 2006

By the way, four or more students from the same company qualify for a 10% discount. If you have 12 or more, an in-house class may make sense. All classes are conducted by either Bill or Daryl.

EDN Magazine EMC Designer's Guide

As many of you know, the *bad news* is that Cahners Publications ran out of the popular *EMC Designer's Guide*, written entirely by Kimmel and Gerke. The *good news* is that they turned the copyright back over to us, with permission to reprint. By the way, the folks at Cahners have been great to work with over the years!

To order your copy, just click on the icon on our web site, www.emiguru.com. The US cost is \$29 (down from \$50), which includes shipping. Discounts available for multiple copies. (For overseas, contact us regarding shipping.) We now accept PAYPAL, so you can even pay right on-line.

Another way to get a copy is to attend on or our classes—we now provide a complimentary copy of the *EMC Designer's Guide* as part of the class materials.

Focus on ESD...

As we approach the Holiday Season, we are also approaching the "ESD Season." At least in North America, where colder temperatures mean lower humidity, usually resulting in a higher number of ESD events. But ESD can be a year round threat, and it manifests its presence anywhere in the world. And when it does, the results can range from simple upsets to permanent damage to components and systems.

Entire books have been written about ESD, so this will be a quick overview. We'll look at some general issues, followed by some design and test recommendations.

ESD as an EMI problem... Before we begin, some brief comments are necessary. Since even small amounts of ESD can damage modern electronic components, most electronics manufacturers have extensive ESD programs in place. These include ionizers, conductive materials (floors, tables, etc.) and wrist straps. The manufacturing goal is *prevention* — of even a single discharge.

In the EMI world, this prevention of a discharge is not considered an EMI problem. When electronic equipment is placed in use, however, we can no longer guarantee that ESD events won't occur. And when such a discharge occurs — often in one nsec or less — it can, and very often does, become a severe EMI problem.

ESD as an EMI Source... Most ESD events result from triboelectric charging. This is commonly created by the separation of two materials. Examples include a walking person (shoes contact and then separate from the floor surface), a rolling cart (wheel contacts and separates from the floor), or even a moving integrated circuit (part contacts and separates from a plastic container.)

Our primary EMI concern is human ESD, since humans will probably touch and use our electronic equipment. Although it may take many seconds (or even minutes) to charge a human, but a discharge last only a few nanoseconds, and can exceed 10 Amps. Not enough energy to harm a person, but certainly enough to damage or upset electronics.

Since the initial human discharge may be about one nanosecond, and since a 300 MHz CW signal has a rise/fall time of about one nanosecond, we often view ESD as a 300 MHz EMI problem. Very fast, and often very nasty!

A KGB Bullet... for Wire Resistance...

—To start, remember that #10 copper wire has a resistance of 1 ohm per thousand feet.

—For every three wire gauges up, the resistance doubles, and for every 10 gauges the resistance is 10 times higher.

—The same rule applies for gauges below #10, but the resistance decreases.

—From a letter by Ned Conklin (KH7JJ) in the June 2005 issue of *QST Magazine*.

ESD and EMI Coupling Paths... ESD can attack our electronics via two major paths — directly by conduction, and "indirectly" by electromagnetic radiation. In fact, this radiation path is now part of the commercial ESD test procedures, and is referred to as the "indirect" test method. By the way, this field coupling is very real — we've seen failures due to the transient fields occur up to 20 feet away.

Furthermore, the direct conduction path can attack both circuit inputs/outputs, and also the circuit power/ground. The former case often results in damage, while the latter is often confined to upset only.

These multiple paths often mean that you may need multiple sets of design fixes - filtering or transient protection for the input/output pins; ferrites or other current limiting for the power/ground paths; and shielding for the radiated path.

ESD and EMI Victims... As already mentioned, ESD can result in both damage and upset. Damage is likely to occur when ESD is injected directly on and unprotected I/O pin of any device — digital or analog. Upset is more likely to affect only fast digital circuits, since most analog circuits are too slow to respond to ESD events.

Circuits that are particularly vulnerable to ESD include Resets, Interrupts, and Control circuits. Unwanted Resets are a very common ESD problem — so common that we routinely add components to Reset circuits to prevent ESD induced events. Interrupts (particularly Non-Maskable Interrupts) often warrant the same attention. Control lines, such as Memory Read/Write, are less common but may also require protection.

Even power circuits may also be vulnerable to ESD. We recently chased an ESD problem that repeatedly caused a power supply to shut down due to false triggering on an input overvoltage protection circuit.

ESD Design Solutions... When analyzing ESD events, it is more useful to consider ESD current, rather than ESD voltage. An ESD event is like a dam breaking in the mountains — once the dam breaks, the pressure (voltage) may be low, but it is the gushing water (current) that causes the damage.

If the current encounters a high impedance, a second high voltage may result — if too high, a voltage "punch through" can occur. If the current encounters low impedances, the high currents can cause damage by simple heating.

As such, you have three choices when dealing with ESD — *prevention, diversion, and limiting*.

— *Prevention* — In this case, insulation or spatial separation is used to prevent an ESD voltage breakdown from occurring in the first place. Keep in mind that at 15kV, an ESD arc can easily jump one centimeter in air — and perhaps more if sharp points (such as screws) are present.



— *Diversion* — In this case, ESD current is diverted from a critical circuit input or output by a transient protector or small capacitor (1000 pF nominal.) In the former case, the transient protector must be fast enough for ESD, which means silicon protectors (Zeners) or surface mount MOVs (metal oxide varistors.) Note that regular discrete MOVs and arc gap devices are generally not fast enough for ESD.

— *Limiting* — This is often used to prevent shunting large currents into the circuit board power or ground distribution. On I/O lines, having 100 ohms of impedance (ferrite or resistor) facing the outside world is adequate to limit ESD currents through a shunt capacitor or transient protector. Separate ferrites may be needed on power or ground lines if they are exposed directly to ESD discharges.

ESD Testing Comments... You don't need to go to an EMC lab, or wait until the end of a project to do useful ESD testing. We are staunch advocates of performing as many "pre-compliance" tests as you can during the design stage. The earlier you start to uncover problems, the more time (and design flexibility) you have to fix them.

As such, you can rent or buy an ESD "gun" that meets the appropriate ESD test recommendations. We usually recommend following the test producers described in EN61000-4-2, the European test method for ESD. Begin with the "indirect" tests, as they are less likely to cause damage (only upsets.) Once hardened for the indirect tests, then you are ready to begin the direct tests.

In both cases, start with a low voltage, and proceed in 2 kV increments. For ESD, it is not adequate to test only at the highest levels — there have been many cases of "windows of susceptibility" at lower voltage levels. Finally, remember that the direct tests may cause damage, so have spare parts available as needed.

Well, we hope you have found this discussion interesting and useful. Please call us if we can help you with any of your EMI needs — ESD or otherwise.

—Great minds talk about ideas.
—Small minds; things.
—Average minds; people.
—Wisdom from a Chinese Fortune Cookie

You Can't...

Drive to work, walk the dog, cook a pot roast, bake bread, shower after jogging, watch television, make toast, brew coffee, mow the lawn, call your mother, be cool in the summer, wash your clothes, dine out, play computer games, build your new house, listen to your stereo, ride your bike, videotape a wedding, vacuum the rug, recycle your garbage, play baseball at night, be warm in the winter, fly to Hawaii, flush the toilet, or use the cash machine...

...without an engineer!!!

(—From a sign in Daryl's office.)

Book Reviews...

Over the years, we have published three books on EMC. (In addition to over 100 technical articles and papers.) Here is some information on our books:

EDN Magazine EMC Design Guide... Originally published in 1994, and updated in 2001. The update included two new chapters, plus new regulatory information. We wrote this as an introductory primer, specifically for the non-EMC engineer. No equations or theory — just simple "tips and techniques" about EMC.

Now available — at a new and reduced price of \$29 — directly from Kimmel Gerke Associates, Ltd. Go to www.emiguru.com and click on the book icon.

Electromagnetic Compatibility in Medical Equipment...

Published in 1995 as a joint project between the IEEE Press and Interpharm Press. This book was an expansion of a series of articles we wrote for *Medical Device and Design Industry Magazine*. Although focused on medical EMC, this book is also applicable to more general EMC issues.

Now available from CRC Press for \$189, although we recently saw it on amazon.com for \$165. The ISBN number is 0-935184-80-5.

EMC Suppression Handbook... This book is a sequential collection of the first ten years of the "EMC Notebook" column, from *Electromagnetic News Report (ENR)*. Each of the articles focuses on a particular EMC issue or problem, with a "lesson learned." Kind of like Aesop's fables for EMC.

Now available from Seven Mountains Scientific (the publisher of ENR) for \$25 plus shipping. Call them at 814-466-6559, or visit www.7ms.com.

Looking for EMC Vendors???

Here are three web sites that may be of interest. These three are affiliated with three leading EMC publications:

—www.ce-mag.com - Compliance Engineering Magazine. (This magazine formerly hosted www.emicatalog.com, which has been shut down.)

—www.interferencetechnology.com - Interference Technology Magazine. Formerly known as ITEM, or the Interference Technology Engineers Master.

—www.conformity.com - Conformity Magazine.

If you are not receiving these magazines, you can sign up on line. All three of the above are FREE.

Application Note...

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 a few years ago, and is now out of print. We have a PDF version, so if need a copy, e-mail Daryl at dgerke@emiguru.com.



How to Contact Us...

Telephone... Toll Free or Direct...

- Answering Service - 888-EMI-GURU (Toll Free)
- Bill Kimmel - 651-457-3715 (Minnesota Office)
- Daryl Gerke - 480-755-0080 (Arizona Office)

E-Mail... A preferred way of reaching us, if you don't need a "real time" answer. Addresses are:

- Bill Kimmel - bkimmel@emiguru.com
- Daryl Gerke - dgerke@emiguru.com

EMI-Toolkit® 2.0...

The updated version of our popular *EMI-Toolkit®* software 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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Snail Mail... If you need to mail or Fed-X something...

- Bill Kimmel, 300 Christine Lane, W. St. Paul, MN 55118
- Daryl Gerke, 2538 W. Monterey, Mesa, AZ 85202

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.

In-House EMC Courses...

Our on-site classes are ever popular, and we can tailor them for your specific needs. We can address *design, systems, and troubleshooting issues*. Most classes run two days, but some opt for a third day for more details. Most clients have us stay an extra day for one-on-one design reviews. Flat rate for up to 30 students, but with even a dozen students, an in-house class often makes sense.



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Daryl Gerke, PE • 2538 W. Monterey • Mesa, AZ 85202
William Kimmel, PE • 300 Christine Lane • W. St. Paul, MN 55108
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Kimmel Gerke Associates, Ltd.

300 Christine Lane
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