

KIMMEL GERKE



Bullets

Winter 2007

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

This KGB discusses "EMC Test Requirements." For many engineers, EMC testing is seen as a "pain in neck", one more hurdle on the way to product release. But paying attention to the EMC requirements can result in products better suited to their final environments. This ultimately means happier customers, less returns, and more revenues.

We recommend using EMC *test* requirements as a basis for EMC *design* requirements. In this KGB, we'll briefly look at the EMC test requirements for a range of different industries, and discuss the objectives, impact, and design solutions for those requirements.

In the meantime, please give us a call if we can help you with any of your EMC issues — design, troubleshooting, or dealing with those ever present test requirements.

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

Seasons Greetings... Our sincere best wishes to you and your families this holiday season, and the best to you in 2007... *Bill & Daryl*

EMC Winter Workshop 2007

San Diego, CA – February 5-6-7, 2007

Orlando, FL – February 12-13-14, 2007

Need a winter break, and some fun in the sun? Want to learn more about EMC design or trouble-shooting?

Then join us in San Diego or Orlando 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.

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—available at both San Diego and Orlando through January 10.)

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...** July 8-13, 2007, at the Honolulu Convention Center, Honolulu, HI. Aloha...

—**EMC Zurich...** September 24-28, 2007, Munich, Germany. (During Oktoberfest... hmmm...)

Public EMC Classes... Here are the cities for the Winter/Spring 2007 schedule for the EMC seminar series co-hosted by Tektronix and Kimmel Gerke Associates, Ltd.

—**San Diego, CA - February 5-6-7, 2007**

Courtyard San Diego Central, San Diego, CA

—**Orlando, FL - February 12-13-14, 2007**

Best Western Lakeside, Kissimmee, FL

Final details are pending for the following cities:

—**Dallas, TX - March, 2007**

—**Atlanta, GA - March, 2007**

—**Philadelphia, PA - April, 2007**

—**Washington, DC - April, 2007**

—**Boston, MA - May 2007**

—**Rochester, NY - May 2007**

For more information on any of these locations, please visit our web site, www.emiguru.com.

By the way, four or more students from the same company qualify for a 10% discount. Also, if you have 10 or more students, it often makes sense to hold an in-house class.

All classes are conducted by either Bill or Daryl.

Revised Format for Public Classes...

Based on student feedback and time concerns, we returned to a TWO DAY format (rather than three day format) for our public classes. As a result, the classes are more tightly focused on design issues, and less on systems issues.

We still cover *Circuits and Circuit Boards, Grounding, Shielding, and Power Electronics*. We've cut back on facility issues like power quality, cables, and lightning. This information is still available for our in-house classes.

New Corporate Address

The Minnesota office has moved to a new location (just a few miles away.) See inside for more details.



Focus on EMC Requirements... In the long run, EMC test requirements result in better products. We've seen this in our own EMC consulting business. Prior to the mid 1990's, we often saw field failures due to nearby radio transmitters. It was not unusual to see equipment fail due to a 1-3 watt hand held VHF radio operating 10-20 feet or more away from the victim.

Since 1996 (when the European Union EMC rules became mandatory) we rarely see these types of failures in the field.

Not only is most commercial equipment more robust against RF fields, they are also more robust against ESD (electrostatic discharge) and most power line disturbances. All this thanks to some simple EMC test requirements.

A word of caution — passing EMC tests is no guarantee that failures will not occur — rather, the tests increase the probability for success. And this is an ongoing effort — as technology and the environments change, so will the test requirements.

In this article, we'll take a brief look at EMC test requirements from two perspectives: commercial/industrial, and military/avionic/vehicular. We'll look at four broad categories:

- RE - radiated emissions
- RS - radiated susceptibility
- CE - conducted emissions
- CS - conducted susceptibility

In all cases, the overall goal is to assure Electromagnetic Compatibility (EMC) — the successful operation of equipment in its intended environment.

RE Requirements - These requirements are designed to protect communications receivers from being jammed by "unintended radiation" from electronic systems.

For commercial/industrial products, this usually means not jamming local TV receivers. For military/avionic/vehicular products, this often means not jamming critical radio receivers, such as communications or navigation receivers.

Since radio receivers operate at lower signal levels than TV receivers, the military/avionic/vehicular test requirements are proportionally lower. Automotive limits are among the toughest, since the radio antennas can be located very close to the offending sources.

A KGB Bullet... Here are some guidelines for Radiated Susceptibility (RS) failure levels:

- **At 0.1-1 volt/meter**, unprotected analog circuits often fail. Symptoms include wild fluctuations in analog parameters such as temperature, flow, etc.
- **At 1-10 volts/meter**, unprotected power circuits (such as voltage regulators) often fail. Symptoms include erratic behavior and failures, such as system lockup.
- **At 10-100 volts/meter**, unprotected digital circuits often fail. Symptoms include repeatable failures, such as resets.

The goal of the test requirements is to keep the unwanted emission levels well below intended signal levels. A typical objective is to maintain 20 dB signal-to-interference level at the receiving antenna. Since source-victim distances may vary, measurement distances may range from one meter (military) to ten meters or more (commercial.)

Design solutions include source suppression of critical circuits (clocks and other repetitive signals), I/O filtering, and shielding of enclosures and cables. With today's technology, a combination of the above is often needed.

RS Requirements - These requirements are designed to protect our equipment against the threat of nearby radio transmitters. Rectification is a common failure mode, with analog and power circuits being particularly vulnerable (see the KGB Bullet.)

For commercial/industrial products, the primary anticipated threat is hand held radios (walkie-talkies and cell phones), resulting in typical test levels of 3-10 Volts/meter. For military/avionic/vehicular environments, higher powered transmitters are assumed, resulting in test levels of 10-200 Volt/meter. For RADAR situations, HIRF (high intensity RF) test levels in the thousands of Volts/meter may apply.

Design solutions include hardening critical circuits at the circuit board level, I/O filtering, and shielding of enclosures of cables. Often times, the RS levels are more demanding to meet than the RE levels.

CE Requirements -These requirements often have two goals: (a) to prevent the power lines from being used as an unwanted "hidden antenna" for emissions, and (b) to protect other equipment sharing the same power circuits.

The former usually applies to commercial/industrial equipment, while the latter usually applies to military/ avionic/vehicular equipment. Thus, these levels may vary widely among environments and across frequencies.

Design solutions include power line filters, and special attention to power supply design. In the latter case, parasitic coupling in the power supply is often a significant contributor to conducted emissions. This may require special shielding and grounding of heat sinks and power transformers.

CS Requirements - These requirements are designed to protect equipment against a myriad of power disturbances, ranging from transients, induced RF, to power line voltage variations (sags, surges, and outages).

Most CS requirements are specific to the environment. In the commercial/industrial world of AC power, these include the EFT (electrically fast transient) and lightning surge. In the vehicular world, these include transients and voltage variations for motor starting, power windows, windshield wipers, and the alternator "load dump". In the avionics/military worlds, the CS requirements address

specific transients and other power disturbances unique to their environments.

Design solutions include power filters, transient protection, isolation transformers, and special attention to power supply design. In fact, both CS and CE requirements are significant considerations for power supplies.

Here are some closing thoughts. Most EMC test requirements have been developed by industry committees, through organizations like ANSI, IEEE, IEC, and the military. These committees strive to characterize the environments, and then come up with test procedures and test levels to screen out likely failures.

The work can be grueling (and thankless) at times, so we all owe a debt of gratitude to those committee members. Even though they are focused on EMC testing, they help all of us design better products. We hope you found this useful, and please contact us if we can help you with any of your EMC concerns.

*The Pessimist complains about the wind.
The Optimist expects the wind to change.
The realist adjusts the sails.*
—William Arthur Ward

As I have matured...

- I've learned that one good turn gets most of the blankets.
- I've learned that no matter how much I care, some people are just jerks.
- I've learned that whatever hits the fan will not be evenly distributed.
- I've learned that you should not compare yourself to others, as they are often more screwed up than you think.
- I've learned we are responsible for what we do, unless we are celebrities.
- I've learned that artificial intelligence is no match for natural stupidity.
- I've learned that 99% of the time when something isn't working in your house, one of your kids did it.
- I've learned that the people you care most about in life are taken from you too soon and the less important ones never go away — and the real pains are permanent.
- I've learned that age is a high price to pay for maturity.
— *E-mail from a friend.*

EMI Suppression Handbook... Still available — the little red book with the great EMI "war stories", written by us and edited by our good friend, Dr. Tom Chesworth. Only \$25 plus shipping. To order, contact Seven Mountains Scientific at 814-466-6559, or visit their web site at www.7ms.com.

Tom (and his better half Josephine) also publish *ENR*, or *Electromagnetic News Report*, a timely and focused newsletter on EMI/EMC issues. The "war stories" are from a regular column in *ENR*.

Bill Has Moved...

The Minnesota office has a new location:
William Kimmel, PE
Kimmel Gerke Associates, Ltd.
628 LeVander Way
South St. Paul, MN 55075

All other contact information for Bill remains the same:
E-mail - bkimmel@emiguru.com
MN Office Direct - 651-457-3715
Toll Free Voice Mail Box - 888-EMI-GURU

The new location is just a few miles from the old location. Please update the new address in your records.

Book Review... In looking back over past KGBs, we just realized we have never reviewed one our all-time favorite EMC books — **Noise Reduction Techniques in Electronic Systems** (2nd Edition), by Henry Ott. Published 1988 by John Wiley, (ISBN 0471850683). Available at www.amazon.com.

This classic is a best seller among EMC books. It is very thorough, and easy to read. It is in our on-line and class EMC bibliographies, and we regularly recommend this as an excellent introduction and design guide for EMC.

From the mail bag... Here are some excerpts from our response to an inquiry regarding 10 MHz damped oscillations seen on the cables of an industrial system:

—Yes, cable pigtails (wires used to terminate cable shields) can cause big problems at 10 MHz. In order for the shield termination to work, the shunt termination must be well below the impedance of the shield-to-wire capacitance. A one foot pigtail has about 240 nH of inductance, which at 10 MHz represents about 15 ohms — not a very good termination.

—Suggest eliminating the pigtails, and using a fully circumferential connection. For experimental purposes, we often use a hose clamp over aluminum foil or braid. By the way, pigtails are fine for 50/60 Hz, but NOT at 10 MHz.

—Also, try connecting the cable shields to ground at BOTH ends of the cable. This does introduce a ground loop, so you may see an increase in the 60 Hz "noise". If so, try replacing the solid ground on one end with a 0.1 uF capacitor. Keep the leads as short as possible. We have used this "hybrid ground" concept successfully on other control systems with similar problems.

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.

In-House EMC Courses... Our on-site classes are very popular. Here are some recent classes we have done for 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 and Mechanical Design (1 day)
- Design for ESD (1 day)

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

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. *You now get this book FREE when you attend one of our classes.*

EMI-Toolkit® 2.0... Check out the updated version of our popular *EMI-Toolkit®* software. This 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*

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