KIMMEL GERKE Bullets

EMI GURU®

Winter 2007/2008

Welcome to KGB...

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

This KGB discusses "EMP", or Electromagnetic Pulse. When we were both young engineers just getting started with military EMC, this was a big issue. The Cold War was on, and the "nuclear" threat was real. EMP was one of several nuclear weapons effects of concern to the military. Over time, the threat abated and the concerns waned.

Now, forty years later, we are again seeing EMP design requirements. While we wish it weren't so, it is still often necessary to design military systems (and other systems critical to our infrastructure) to withstand these effects. A big concern now is from rogue nations — one high altitude burst over Europe or off the North American coast could wreak havoc in today's electronic world. So we will take a quick look at this reemerging EMC threat.

In the meantime, please give us a call if we can help you with any of your EMC issues — military, commercial, medical, industrial, vehicular, or ??? We're here to help.

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 in 2008... *Bill and Daryl*

EMC Winter Workshops 2008

Orlando, FL - February 11–13, 2008
San Diego, CA - February 18–20, 2008

Need a winter break, and some fun in the sun? Want to learn more about EMC design or troubleshooting? 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 trouble-shooting class is offered ONLY at these locations, as an optional extension to the two day class. If you have already attended a two day class, you are welcome to join us for this additional day.

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 in Orlando, good through January 26.)

Shows and Conferences...

Call us if you'd like more details.

- **IEEE Symposium on EMC - October 18–22, 2008**
  Cobo Center, Detroit, MI.

Public EMC Courses...

Here are the cities for the Winter/Spring 2008 schedule for the EMC seminar series co-hosted by Tektronix and Kimmel Gerke Associates, Ltd.

- **Orlando, FL - February 11–13, 2008**
  Best Western Lakeside, Kissisimme, FL
- **San Diego, CA - February 18–20, 2008**
  Arrow Electronics Inc., San Diego, CA

Final details are pending for the following cities:

- **Dallas, TX - March, 2008**
- **Huntsville, AL - March, 2008**
- **Long Island, NY - April, 2008**
- **Washington, DC - April, 2008**
- **Boston, MA - May, 2008**
- **Rochester, NY - May, 2008**

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.

KGA Twenty Years in Business...

How time flies! In October, we celebrated 20 years in business. As some of you know, our first day in full time practice as EMC consulting engineers was the day the market crashed in October 1987. No, we don't think we caused the crash, but it was sobering — at least we got the most frightening day in business over with right away!

Since then, we've worked on hundreds of EMC projects, and taught thousands of you the intricacies of EMC, and how to identify, prevent, and fix those problems in your designs. It has been great fun — and **THANK YOU** to all of you for your support and business these past 20 years.

Kimmel Gerke Bullets is a free newsletter on Electromagnetic Interference/Compatibility (EMI/EMC).
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Focus on EMP...

When most of us think of nuclear weapons effects, we think of the local effects like blast, temperature, and radiation. But thanks to EMP (electromagnetic pulse), electronic systems can be upset or damaged thousands of miles from a detonation. The military has been concerned about EMP for many years, but EMP can also affect non-military electronics, such as telecomm and power systems. As such, systems critical to civilian safety should (and often do) include EMP hardening as well.

EMP is produced when the gamma rays from a nuclear detonation produce high energy free electrons. There are four modes of EMP to be considered: surface burst, low altitude burst, high altitude burst, and outer space burst. The first three can affect terrestrial electronics (ground or air), while the last affects only space electronics..

Surface and Low Altitude Bursts — This threat is of primary concern to hardened military sites, such as missile silos. These EMP effects are fairly local, typically within the range of physical damage. Levels can range from 10 kV/m to 1 MV/m, with rise times in the nanoseconds. Commercial facilities would likely be physically destroyed within the range of surface and low altitude bursts.

High Altitude EMP — Often referred to as HEMP, this threat affects both military and commercial systems. Levels can reach 25 – 50 kV/m, with ranges extending over thousands of miles. For example, a high altitude burst at 300 miles would have an expected range of almost 1500 miles, enough to cover the entire US or Europe.

HEMP has some interesting physics. The gamma rays from a high altitude burst produce high energy electrons by "Compton scattering". At altitudes between about 10 – 20 miles, these electrons become trapped in the earth's magnetic field in spiral patterns, resulting in a transient oscillating current with rise times under 2 nanoseconds.

Due to these high levels, fast risetimes, and wide geographical coverage, HEMP can induce large currents and voltages in communications cables, power lines, and radio towers. Other "collectors" of HEMP energy include pipelines, metal fencing, wires in buildings, and railroad tracks. Even underground conductors are not immune. The resulting surges can easily destroy today's sensitive electronics — both military and commercial.

A KGB Bullet...

As our EMI problems move up in frequency, it may be helpful to know the microwave band designations. Here they are:

- L Band	1 GHz – 2 GHz
- S Band	2 GHz – 4 GHz
- C Band	4 GHz – 8 GHz
- X Band	8 GHz – 12 GHz
- Ku Band	12 GHz – 18 GHz
- K Band	18 GHz – 27 GHz
- Ka Band	27 GHz – 40 GHz

As such, a single HEMP event could destroy unprotected power and telephone systems, and could cripple railway networks and other processes. Unfortunately, this does not necessarily mean nuclear war — a terrorist or rogue nation could easily cause widespread havoc with a single weapon.

Space EMP — This threat is confined to military and commercial satellites and spacecraft. Since there are very few molecules in space, the primary space EMP effects are due to gamma rays inducing current pulses in structures and electronic systems. This phenomena is often referred to as SGEMP, or "Systems Generated EMP".

EMP Requirements — The military has incorporated EMP requirements at both the systems and box levels. System level requirements are often classified, as they reveal system level vulnerabilities. At the box level, however, MIL-STD-461E includes non-classified test requirements based on EMP levels. These include RS105 and CS116.

RS105 is intended to simulate the free field EMP environment. The test pulse reaches 50 kV/m in about 2 nsec, and then tapers off exponentially to 25 kV/m in about 25 nsec. This is usually applied only to enclosures.

CS116 is intended to simulate currents induced on cables and power leads during EMP events. The test waveforms are damped sine waves, ranging from 10 kHz to 100 MHz with amplitudes up to 10 amps.

Most military electronics are subject to these requirements. For those in the commercial world worried about EMP, these tests would be very suitable. Since they are standard tests, any EMI test lab should be able to perform them.

EMP Hardening — Due to the high levels, high frequencies, and fast rise times, EMP hardening can be a challenge. Standard commercial EMI practices will likely not suffice, and even military EMI practices may not be fully adequate. Here are some design recommendations:

Shielding — Multiple levels of shielding are often used. Welded steel is commonly used at the facility level. All conducting penetrations (cables, power, pipes, etc.) and apertures (doors, windows, vents, etc.) must be treated.

This typically includes filters on power and signal lines and full circumferential bonding of pipes and cable shields. Windows and vents must be screened, and doors must be gasketed. Doors often use vestibules to provide "waveguide beyond cutoff" protection and assure at least one door is always closed.

Equipment level shielding follows the same practices — solid metal with welded seams preferred, filters on power and signal lines, and aperture protection. If the equipment is used inside another enclosure, the equipment shielding requirements are often relaxed.

Transient protection — High speed transient devices are often used on power and signal lines. Zener devices like

Tranzorbs® are very well suited for EMP. Conventional power transient devices, such as MOVs or gas tubes, are generally too slow for EMP. Due to the high frequencies, low inductance ground connections are mandatory.

Cables and Connectors — Since cables are the primary "collectors" of EMP energy, they deserve special attention. Solid shields or conduits may be necessary for cables external to a facility. Even those inside need to be of high quality, with a low "transfer impedance" to 100 MHz and beyond. Cables and connectors require a full 360 degree termination — no "pigtails" or "drain wires" allowed.

Board Level Protection — Hardening techniques for lightning and ESD are also suitable for EMP. This includes filtering of critical circuits like resets, interrupts, and control lines. I/O and power lines should also have filters and transient protection at the board interfaces.

We hope this has proved interesting and useful. While most military designs have some EMP hardening, sensitive commercial designs should consider also consider the EMP threat. Finally, we truly hope none of this is ever needed.

> One good thing about being wrong is the joy it brings to others. — *Author Unknown*

Top Ten Things Engineering School Did Not Teach...

10. There are least 10 types of capacitors.
9. Theory tells you how a circuit works — but not why it does not work.
8. Not everything works per the specs in the data book.
7. Anything practical you learn will be obsolete before you use it, except complex math, which you will never use.
6. Always try to fix the hardware with software.
5. Engineering is like having an 8 AM class and a late afternoon lab for every day the rest of your life.
4. Overtime pay? What overtime pay?
3. Managers, not engineers, rule the world.
2. If you like junk food, caffeine, and all nighters, go into software.
1. Dilbert is a documentary.

Some Interesting EMI News...

Nissan North America recently warned customers not to place electronic car keys close to a cell phone. They advise keeping the car keys at least an inch away from cell phones to avoid disabling their "intelligent car keys."

The problem has been discovered with the 2007 Nissan Altima and the Infiniti G35 sedans — two of Nissan's most popular models. If the I-key touches the cell phone, incoming or outgoing calls can alter the electronic code in the I-key. The result is the car won't start, and the key can not be reprogrammed. Nissan will provide new keys to customers who encounter the problem. (We wonder if some EMI engineer at Nissan is in hot water over this?)

Book Review...

RF Exposure and You, by Ed Hare, published by the American Radio Relay League. ISBN 0-97259-662-1. Available at www.arrl.org.

Comprehensive, yet easy to read. Although developed for the amateur radio community, this book should prove useful for anyone interested in RF exposure to humans. The book includes relevant FCC rules, and FCC OET 65.

From the mail bag...

Here is an interesting e-mail from one of our readers:

"My son-in-law called the other day to ask why his garage door opener would only work only once every five minutes or so. I asked the usual questions about good batteries, etc. They even had purchased a new remote control with the same results. Well, I said I would think about it.

"He called back the next day and said he solved the problem. Being energy conscientious, he had replaced the unit's incandescent bulbs with fluorescent lamp bulbs, but had not noticed any problems at the time. When he put the standard bulbs back in, the problem was gone.

"Apparently the CF bulbs were generating enough EMI that it desensitized the receiver in the overhead door opener. Only when the CF bulbs were gone did the remotes work."

Thanks, Steve Coan. With the lamps right next to the receiver, even RF emissions well below the FCC limits could easily cause a problem. We once saw a similar problem when the garage door opener manufacturer added a new feature using a 4 bit microprocessor. Both are good examples of the "Law of Unintended Consequences."

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*.

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)

For more information on either version, call us at 1-888-EMI-GURU, or e-mail *bkimmel@emiguru.com**

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- Daryl Gerke - 480-755-0080 (Arizona Office)

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

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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.

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. *Attend a class and get a FREE copy of this book.*

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 for Mechanical Engineers (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.

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FIRST CLASS MAIL

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