KIMMEL GERKE Bullets

EMI GURU

Summer 2008

Welcome to KGB...

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

This KGB focuses on shielding, an area that often causes confusion. Since shielding bridges both mechanical and electrical issues, it usually requires an interdisciplinary approach. Shielding is sometimes seen as a "Band-Aid", but we believe it is an important facet of EMC design.

We'll look at both materials selection and mechanical design. We'll see that shielding is highly dependent on both frequency and impedance, and that mechanical dimensions (such as hole sizes) can be very important.

We hope you enjoy this issue of the KGB. As always, give us a call if we can help you out with any of your EMI problems — electrical, mechanical, testing, and more.

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

IEEE EMC Symposium...

August 18–22, 2008, at the Cobo Center in Detroit, MI. Hope to see many of you at the show!

Please Requalify...

It is that time of year again, when we ask you to requalify. You can do so on line at *www.emiguru.com/register.htm*, or you can send in the enclosed card if you received this by snail mail. (Not necessary if you have signed up recently, or attended a seminar in the past year.)

Please include your E-MAIL address, plus your current SNAIL-MAIL address. Since many company firewalls block outside messages, your HOME e-mail is a good idea. Your HOME snail-mail address is OK, too.

Well over half of our subscribers now receive the electronic version of the KGB. We thank you... it saves us money on postage and printing, and it lets you store them or forward them to your friends and colleagues. Thus, e-mail will be the preferred medium.

Our Privacy Policy — Our list is PRIVATE. In addition to the KGB notices about twice a year, we will also let you know when we are holding a class in your vicinity.

Public EMC Courses...

Here are the cities we have selected for the Fall 2008 EMC seminar series co-hosted by Tektronix and Kimmel Gerke Associates, Ltd. We've been doing these popular seminars since 1992, and have provided practical EMC training to thousands of your colleagues.

- **Seattle, WA - September 9–10, 2008**
  Carlton Inn at Totem Lake - Kirkland, WA
- **Denver, CO - September 15–16, 2008**
  Courtyard by Marriott - Louisville, CO
- **Chicago, IL - September 29–30, 2008**
  Hampton Inn - Schaumburg, IL
- **Minneapolis, MN - October 2–3, 2008**
  Courtyard by Marriott - Roseville, MN
- **St. Louis, MO - October 7–8, 2008**
  Courtyard by Mariott - Earth City, MO
- **San Jose, CA - October 30–31, 2008**
  Courtyard by Marriott - San Jose Airport
- **Los Angeles, CA - November 6–7, 2008**
  Courtyard by Marriott - Irvine, CA
- **Phoenix, AZ - November 17–18, 2008**
  Freescale Semiconductor - Chandler, AZ

For more information, please visit our web site, *www.emiguru.com*, or call 1-888-EMI-GURU. Please note you can also register on-line, using our secure registration.

In-House EMC Courses...

Our on-site classes are also popular. Here are some recent classes we have done for clients:

- **Design for EMC (2 days)**
- **Design & Troubleshooting EMC (2 days)**
- **EMC Design, Systems, & Troubleshooting (3 days)**
- **Medical Design for EMC (2 days)**
- **EMC in Vehicular Electronics (2 days)**
- **EMC in Military Systems (2 ½ days)**
- **EMC in Avionics Systems (2 days)**
- **EMC in Systems (1 day)**
- **EMC Grounding & Shielding (2 days)**
- **EMC and Signal Integrity in PCBs (1 day)**

We can customize to meet your special needs. You supply the meeting space — we supply the materials and the instructor (either Bill or Daryl.) *Flat rate for up to 30 students, but with even a dozen students, an in-house class often makes sense.*

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

At first glance, shielding seems so simple. Just build a box and seal it up, right? But questions quickly arise. How much shielding is needed? What materials to use? How to handle openings, seams, and penetrations? Suddenly, a simple problem becomes complex. Just hanging sheet metal on a frame won't do the job.

In this article, we'll share some shielding design concepts. Properly done, your shield can provide over 100 dB (100,000 X) of attenuation. But if you are not careful, that 100+ dB shield can be turned into a 20 dB shielding wimp. The differences are often subtle, but simple.

Multiple shielding mechanisms... One reason shielding can be confusing is that there are several mechanisms at work. The two main factors for EMI shielding are "reflection" and "absorption." The first behaves like a mirror, and the second behaves like insulation in a wall.

It turns out that "reflection" is the main mechanism for RF shielding (frequency >10 kHz) while "absorption" is the main mechanism for power frequency magnetic field shielding (frequencies of DC/50/60/400 Hz typical.) As a result, different designers may have different shielding opinions based on their own background and experience.

How much shielding is needed... A simple answer is "enough to do the job." The shield is a barrier, and must reduce internally generated fields to acceptable levels, and also provide adequate attenuation against external fields.

The precise levels are often difficult to predict, so we usually rely on EMI testing to determine if the we have adequate shielding. Sometimes that data comes a bit late.

Nevertheless, here are some typical shielding design guidelines for today's technology:

- Commercial — 30–60 dB typical (30–1000X)
- Military — 60–90 dB typical (1000–10,000X)
- Special — 90–120 dB (10,000–1,000,000X)

Two additional notes. First, simple embedded controllers (processors running under 10–20 MHz) may need no shielding (assuming special care in circuit board design.)

Second, a practical upper limit for equipment shielding (and shielded rooms) is about 120 dB, due to mechanical issues like seams and penetrations.

A KGB Bullet...

When dealing with power/grounding issues, we find it helpful to evaluate at least three frequencies:

- Low – Power frequency – DC, 50/50 Hz, or 400 Hz
- Medium – Transient frequency – 1 MHz*
- High – Emissions/immunity – 100 MHz**

*Use 60 MHz for EFT (Electrical Fast Transient)

**Use 300 MHz for ESD, or the actual frequency if dealing with a specific emissions/susceptibility problem

Materials selection... For RF shielding, almost any thin conductive material will suffice. This includes metal foils and even conductive coatings on plastics. For example, aluminum foil provides almost 100 dB (minimum) of protection, while even thin conductive coatings often provide 60–80 dB of attenuation.

For power frequency magnetic field shielding, however, "electrical thickness" is needed to provide the necessary absorption. Aluminum foil is virtually transparent to power frequency magnetic fields, as are the thin conductive coatings. In fact, it may take several inches of aluminum (or copper) to begin to attenuate a 60 Hz magnetic field.

The solution for power frequency magnetic fields is to use permeable material. Like the wall insulation R-factor, the "electrical thickness" is boosted by the square root of the relative permeability (mu). Thus, steel with a mu of 1000 will provide the same low frequency shielding performance as about three inches of copper or aluminum. Mu-metals, with permeablilties of up to 100,000, do even better.

For an enclosure, 1/10 inches of steel is practical, but 3 inches of aluminum is probably not practical. This is why steel or other permeable materials are favored for power supplies, while aluminum or thin coatings are often used for equipment enclosures.

Mechanical issues... For RF shielding, the biggest concerns are mechanical. The two problem areas are openings and penetrations. Even small openings or penetrations can be problematic — for example, at 1 GHz, a ¾ inch opening only provides about 20 dB of attenuation. That same opening at 10 GHz provides ZERO attenuation.

Finally, the longest dimension is critical. For example, under worst case conditions, a one inch seam leaks the same as a one inch hole. The seam leakage is polarized while the hole is not, but we are typically pessimistic with EMI design. After all, Murphy will make sure the worst case occurs during testing.

Shielding design solutions... Here are some design ideas your EMI shielding:

Materials... Thin conductive materials are fine for RF shielding, but permeable materials are needed for low frequency magnetic fields (such as power supplies.)

For plastic cases, EMI liners are becoming popular to meet the European RoHS (Restriction of Hazardous Substances) requirements. These can be metal, metallized plastic, or even using conductive wallpaper technology. If the liner can be easily removed, the remaining plastic is recyclable.

Seams... Consider EMI gaskets to seal the seams. Clean metal-to-metal contact is a must. For moderate shielding, gaskets may not be necessary. Consider interlocking seams or screws to maintain pressure on the seams. Of course, welded seams provide the ultimate protection.

Openings... Visual openings can be sealed with conductive glass or panels with fine screen. Ventilation openings can be sealed with screening, or even small perforations in a metal enclosure. In all cases (except the perforations) the joints must also be sealed to the enclosure metal.

Penetrations... For best performance, any metallic penetrations, including cable shields, should have a full circumferential termination at the enclosure. Drain wires (often called "pigtails") greatly degrade both cable and enclosure shielding at high frequencies.

For unshielded or poorly shielded lines (such as power or low bandwidth I/O), filters help seal the penetrations at high frequencies. You can always trade-off filtering and shielding for signal and power interfaces.

Multiple shields... Finally, you don't need all the shielding at the enclosure. Internal shields on circuit boards, or over internal modules, can help. Think of the TV tuner.

We hope this has been helpful. Please contact us if we can help with your EMI problems... shielding or otherwise. We typically examine shielding during an EMI design review.

Engineers aren't boring people. We just get excited over boring things. –Anonymous

How to tell if your child (or grandchild) is going to be an engineer...

- You buy your child an educational software program, and she wants to know which authoring tool it was written in.

- He throws a tantrum every time you refuse to take him to Fry's Electronics.

- She can reprogram your VCR, and you can't get it to stop blinking "12:00".

- He has removed the voice box from his Talking Elmo and has reprogrammed it to recite the periodic table.

- She has replaced the arms and legs of her Barbie doll with bionic limbs.

- He has Bill Gates posters in his room.

- Forget Dr. Seuss and Beatrix Potter. She wants you to read Carl Sagan.

- He gets into fights at school because he owns a PC, and the other kids use a Mac. — *From the Internet*

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.

Book Reviews...

Although not technical, the following two books should be of interest to any engineer. Richard Florida, a professor at George Mason University, examines the rise of a new social class he calls the "creative class."

Members include scientists and engineers — those who create new ideas and technology. He discusses both local trends (such as the cities we prefer) and international trends (such as our overseas competition.) Lots of tables and good data. Well written and thought provoking.

The Rise of the Creative Class focuses on his initial findings, and their relevance to the United States. Harper Business, 2003, ISBN 0465024773.

The Flight of the Creative Class expands internationally, as he takes his arguments to the next level. Harper Business, 2005, ISBN 006075690.

You can also check his web site: *www.CreativeClass.org*.

From the E-Mail Bag...

Here are a couple of questions we recently received, that may be of interest to others:

(1) *Is it common to use three MOVs (Metal Oxide Varistors) to protect against power line surge protection (hot-neutral, hot-ground, neutral-ground)?*

(2) *A coworker is concerned about using the MOVs to ground in case they short. Is this a safety concern?*

Yes, it is common to use three MOVs (or other transient protectors, such as gas tubes or silicon devices.) The line-line devices provide "differential mode" protection, while the line-ground devices provide "common-mode" protection. (Note that the line-ground protectors also provide line-line protection, but at twice the nominal breakdown voltage.)

We typically suggest the three-device approach. Our feeling is that the line-line approach only addresses half the problem. Regarding the safety concerns, we usually suggest placing the transient protectors after any input fuses. Thus, if there is a short, the fuse should provide over current protection.

An additional word of caution. If you are marketing to Europe, you may not be allowed to use MOVs or silicon devices as a line-ground protector, unless they are in series with a gas tube. The concern is a potential shock hazard if a short occurs. This is generally not a concern for US products, due to different methods of safety grounding. (That may be the source of the coworker's concern.)

Finally, a brief disclaimer. We ALWAYS recommend you review all of your power related concerns (transient protection, creepage, clearance, etc.) with a cognizant safety engineer or safety agency. Remember, when dealing with power issues, safety must always prevail over other design issues, including EMI/EMC.

About Kimmel Gerke Associates...

We are often asked to give a quick description of what we do and who we are. If you are asked by someone needing EMI help, here are several key points about KGA...

Point I... We are a two-man **electrical engineering firm that specializes in consulting & training on EMI/EMC (electromagnetic interference and compatibility) issues.**

These include five key areas:

- **Regulatory Compliance** (Emissions, immunity, FCC, CISPR, IEC, CE, MIL-STD-461, DO-160, SAE, etc.)
- **Radio Frequency Interference** — (RFI)
- **Electrostatic Discharge** — (ESD)
- **Power Disturbances** — (Transients, magnetic fields, etc.)
- **Self Compatibility** — (Signal Integrity, Analog, etc.)

Point II... We are Registered Professional Engineers (PE) and NARTE Certified EMC and ESD engineers. **Between us, we have over 80 years of industry experience.**

Point III... We are not a test lab — **our emphasis is on EMC design, troubleshooting, and training.** While we are knowledgeable on EMC tests and regulations (and regularly witness EMC testing for our clients), our primary focus is on design/systems issues, and **how to identify, prevent, and fix EMI problems.**

Point IV... We serve many industries, and our support ranges from circuit boards to complete systems.

- **Military/Aero** (MIL-STD-461, TEMPEST, EMP, etc.)
- **Avionics** (DO-160, MIL-STD-461, etc.)
- **Computers** (FCC, EU, PCs to supercomputers)
- **Industrial Controls** (Individual controls to full systems)
- **Vehicular** (SAE, automobiles, farm machinery, etc.)
- **Medical** (FDA, diagnostic, clinical, patient connected)
- **Telecommunications** (GR-1089, etc.)
- **Facilities** (Shielded rooms, lightning, power)
- **Site Surveys** (RF, magnetic fields, mitigation help)

Point V... We are an independent consulting firm with no outside affiliations. **Our advice and recommendations are free from any bias or other business concerns.**

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