Kimmel Gerke Bullets

EMI GURU®

Winter 2014

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 focuses on Cables and Connectors. Often overlooked but always important, particularly at the systems level. Cables often act as "hidden antennas" at high frequencies, and "hidden ground loops" at low frequencies. And connectors often act like "leaky faucets."

We often joke that repeatedly solving cable/connector problems helped put four kids through college. We touched on this topic some years ago, but it bears repeating again.

Hope you find the review helpful. But from systems to circuit boards, give us a call if you need EMI help.

– Daryl Gerke, PE, and Bill Kimmel, PE

Webinars... Plans are afoot to resurrect our webinar program in 2014. We have several topics in mind. Watch our web site, or join our mail list for the latest details.

EMC Winter Workshops 2014
San Diego, CA - February 11-12-13, 2014
Orlando, FL - February 18-19-20, 2014

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 troubleshooting class is offered ONLY at these locations, as an optional extension to the two day class. We recommend attending the two day class Design prior to attending the Troubleshooting 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 in Orlando.)

Season's Greetings... Happy Holidays from our families to yours. Wishing you the peace and the joy of the season, and all the best in 2014!

Upcoming Events.. Here are some places we'll be in 2014. Hope to see you at one or more of these events.

EMC Winter Workshop-San Diego CA-February 11-13.
Daryl will be teaching this class. Combine this with a mini-vacation to see the San Diego Zoo, Sea World, or (like Daryl does) the wine country of Temecula.

EMC Winter Workshop-Orlando FL-February 18-20.
Bill will be teaching this class. Take a mini-vacation to Disney World (like Bill does) before or after this class.

EMC Seminar-Milwaukee WI-March 25.
Daryl and Bill will tag-team four sessions at this one day special event sponsored by the Milwaukee EMC Society chapter.

EMC in Military Systems-Chantilly VA-May 20-22.
One of us will again teach this new three day class in the Washington DC area. Includes EMI Troubleshooting and the Design Impact of MIL-STD-461 and MIL-STD-464.

IEEE EMC Symposium-Raleigh NC-August 4-8.
The annual rendezvous for those interested in EMI/EMC. Meet old friends, learn new ideas, see new products, and more. If you are new to EMC, this is a great show to attend, as it is a friendly bunch that welcomes newcomers.

EDN Designer's Guide to EMC...

Now available in PDF. Written entirely by Kimmel Gerke Associates. First published in 1994, and updated in 2001 (three new chapters.) Order on-line at *www.emiguru.com*, for $29, and download immediately.

Hard copies still available for $39, which includes US shipping. Call for details, or special pricing on multiple copies. *Attend a class and get a FREE hard copy.*

Please Join our E-Mail List... About half of you are already on our electronic list, and we invite the rest of you to join us. *Multiple benefits - you will learn about:*

- On line EMC events, like webinars.
- Local public EMC events, like our classes.
- Other EMC issues/events that may be of interest

You will also receive a notice/link for the latest KGB.

We won't spam you, and you can opt-out at any time. Our E-mail list is private, and we do not sell or rent names. *Join us - - keep up to date on EMC, and also save a tree or two.*

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Focus on Cables & Connectors...

Often overlooked, cables and connectors are very important. They are much more than a simple collection of wires and connectors. This is particularly true at the systems level.

Although we addressed this back in 1996 (where has the time gone, anyway???) we decided it was time to review this important topic again.

The reason -- some recent consultations, plus the high level of interest in cables/connectors we've seen in our *EMC in Military Systems* classes *(See the Bullet for more info.)*

Cables as "hidden antennas" - We consider cables potential antennas when their length is over 1/20 of a wavelength. That means about six inches for 100 MHz signals, but about 100 miles for 60 Hz power.

Thus, if you're worried about RF issues (emissions or immunity), you cables may well be antennas. If you're worried about 60 Hz coupling, antenna effects are probably not a concern.

Cables as "hidden ground loops" - Since ground loops prevail at lower frequencies (< 10 kHz), this is often a concern with low level analog circuits (instrumentation, audio, etc.) As such, we usually don't worry about ground loops with digital circuits, where antenna effects prevail.

Both signal grounds and shield grounds must be addressed, however, as both can provide unwanted sneak grounding paths. This is the realm of power frequencies.

Connectors as "hidden leaky faucets" - With shielded cables, the connectors MUST be properly terminated. The higher the frequency, the more important this becomes.

Cable shields are like water hoses – even the best cable will fail if the "faucet" leaks. This is the realm of RF and ESD.

Cables design guidelines - By now it should be apparent that *cable design is affected by frequency*. One size does not fit all situations. Here are five design issues:

Shielding vs. Filtering - First, determine the bandwidth needed on the interface, and then filter frequencies above the bandwidth. For analog interfaces, this will often be below 10 kHz. For digital interfaces, you can use five to ten times the data rate as a starting point.

For example, a 1 Megabit MIL-STD-1553 interface can be filtered above 5-10 MHz. However, a 100 Megabit Ethernet interface probably can not be filtered and must rely solely on shielding. These are solutions we have applied in past troubleshooting consultations.

Cable shielding - If you need shielding, how good must it be? Once again, that depends on the threat frequencies. In most cases, the higher the frequency, the leakier the shield. An exception is solid shields, which actually improve with frequency due to the skin effect.

- *For frequencies below 1 MHz*, just about any old braided shield will work. Save your money here.

- *For frequencies above 10 MHz*, however, higher quality shields are needed. These include tighter braids (higher optical coverage), double braids, braid over foil, or even solid materials. Spend your money here.

Cable grounding - This issue immediately raises several questions. If shielded, should I ground one end or both? Should I connect to the cabinet, or the circuit? Can I use "pigtail" connections? Regardless of cable shielding, what about the signal grounds?

Once again, the best approach depends on the threat frequencies, and also the length of the cable.

- *For frequencies below 10 kHz*, the preferred approach is to ground both signal grounds and shield grounds (if used) at one end. The goal is to prevent ground loop coupling through these ground paths.

The preferred connection point is the circuit ground, although the cabinet ground is often satisfactory. Pigtails are OK at low frequencies, as the inductance is minimal.

Here is a special exception for shield grounds at low frequencies. For strong low frequency magnetic fields, grounding on both ends often works better. Forcing a ground loop partially cancels the magnetic fields.

We've seen this used in power substations. For full protection, double shields are often used. The outer shield (magnetic fields) is grounded at both ends, while the inner shield (electric fields) is grounded at one end.

- *For frequencies above 10 kHz AND/OR cable lengths over 1/20 wavelength*, the preferred approach is to ground both ends AND to provide full circumferential terminations (NO pigtails) to prevent leaks at the connector.

- *For both low and high frequencies*, you may need a hybrid ground. Solidly ground one end, and then connect the other end though a capacitor (1,000 - 10,000 pF typical.) Keep the leads short to minimize the inductance.

As an alternate for this case, consider double shields. The outer (high frequency) shield is connected at both ends. The inner (low frequency) shield is connected at one end. The two shields must be insulated from each other.

Connector terminations - Although last, this is not least. In fact, improper connector terminations are a major factor in cable shielding failures at high frequencies. We've seen 20 dB increased emissions, and 10 fold reduced RF immunity or ESD due to poor terminations.

- *For high frequencies* you need a full circumferential bond between the shield and the connector. This continuity must be maintained through the connectors to the cabinet.

This means full metal-to-metal connections, often augmented with EMI gaskets. Watch out for corrosion, which can severely degrade these connections.

- *For low frequencies*, you can relax, particularly at power frequencies. Pigtails are fine, as both the inductive and transmission line effects are minimal at these frequencies.

Summary - Hope you found this review helpful. Give us a call if you need EMI help, from circuits to systems, and from designs to disasters.

Silence is golden
But duct tape is silver
(Thanks Lisa B.)

Visit www.emiguru.com ... As we continue to update and improve our on-line EMI collection.

Currently working on...
– Library of past articles and papers by Kimmel & Gerke
– Searchable vendor data base (including test labs)

FREE STUFF already on our web site...
–Past KGBs (20 years worth)
–EMC bibliography (Books, periodicals, useful web sites.)
–Espresso Engineering videos with both Bill & Daryl
–EE-Web Magazine interviews with both Bill & Daryl
–Info about Kimmel Gerke Associates services.

NOT FREE, but useful...
– Class info - dates, locations, and on-line registration
– Books we've written - two in PDF with on-line ordering
While there, join our E-Mail list so can stay in contact!

A KGB Bullet... Application Note

EMI Design Technique for Microcontrollers in Automotive Applications - Intel AP-711

We continue to get requests for this applications note that we helped write some years back. The general concepts still apply today to a wide range of embedded controller applications.

For a PDF copy, e-mail Daryl at *dgerke@emiguru.*

Consider In House EMC Training...

You may have noticed our public class schedule has shrunk in the past year or two.

Due to the economy, revenues are down as companies tighten training and travel budgets. At the same time, the expenses (promotion, hotels, catering, etc.) continue to go up. Thus, we've had to cut back the classes.

Simply stated, the old public model no longer works as well for us. While we enjoy the teaching, we still run a business, and our classes must carry their own weight.

NO, we are NOT getting out of the training business!!! We remain as committed as ever to helping our clients prevent EMI problems through EMI education. We will continue with our public classes, but at a lower level.

Our NEW EMPHASIS, however, is on IN-HOUSE CLASSES... So if you want to take advantage of over 90 years of industry experience combined with teaching over 10,000 students, call us to get on our schedule.

But don't wait too long. We won't be doing this forever. After all, we just celebrated 26 years in full-time practice. We also just celebrated 21 years of our *Design for EMC* classes. We won't be doing this in 20 years from now.

Not to sound immodest, but we're at the top of our game. As such, it is a great time for you to tap into our collective EMI/EMC experience. After all, the problems are not going away anytime soon.

BREAK-EVEN is about 12 students... We train up to 30 students at a fixed fee (no per-seat fees). You provide the training space, A/V, and refreshments. We provide the materials and instructor.

An added advantage is that we can tailor material to focus on your particular problems. We can also add design reviews. BTW, our in-house classes continue to do well.

Don't have 12 students? Share a "hybrid" class with other local companies. Similar to an in-house class, but we request only one payment (you work out the money split.) We've done several such classes with good success.

The PAYBACK for EMC training is there... Save one trip to the test lab, and you have probably recovered the class fees. Any savings after that are 100% profit.

But it is not just test savings. One client told us that preventing just one equipment shutdown saved $50K. Another client told us that getting to market one month early was - as the credit card people say - *priceless!*

Interested? Call us at 888-EMI-GURU... *The first six classes directly booked for 2014 will receive a 10% "early bird" discount off the class fee. Call today! (Discount Expires 4/1/2014).*

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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, FDA, MIL-STD, RTCA, 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 iNARTE Certified EMC engineers. **Between us, we have over 90 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)
- **Legal Support** (Patent help, expert witness)

Point V... We are an independent consulting firm. **Our advice and recommendations are always free from any bias or other business concerns.**