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 75 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 (BELLCORE 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.**

Kimmel Gerke Associates, Ltd.
300 Christine Lane
W. St. Paul, MN 55118

1-888-EMI-GURU

FIRST CLASS MAIL

KIMMEL GERKE Bullets

EMI GURU®

Summer 2006

Welcome to KGB...

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

This KGB discusses signal filters. These simple circuits and devices are among our primary defenses against EMI. Filters can be applied directly at circuits, or at connectors. We often refer to the latter as "filter at the periphery." It works at the board, box, and systems level.

Although the circuits can be simple, they must still be properly designed, installed, and grounded. We will give you some guidelines for these important issues.

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—from individual circuits to full blown systems.

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

Application Note...

We still get requests for the Intel Application Note *(AP-711 - EMI Design Technique for Microcontrollers in Automotive Applications)* that we helped write some years back. The general concepts still apply today to a wide range of embedded controller applications. We have a PDF version, so if you need a copy, just e-mail Daryl at *dgerke@emiguru.com*.

EDN Magazine Designer's Guide for EMC

Although no longer offered by Cahner's Publications, we are now publishing this classic design guide—written entirely by Kimmel and Gerke, and updated in 2001. (Cahner's graciously returned the copyright to us.)

To order a copy, visit our web site at *www.emiguru.com*. This is virtually identical to the original—even the color. The price, however, is less—only $25 (+$4 S&H) instead of $50. Better yet—attend one of our EMC classes, and receive your own copy FREE with the class.

We also have special pricing for multiple copies, so you can equip ALL your engineers with this practical EMC guide. (Several companies have already done this .)

For more details, visit www.emiguru.com, or give us a call (toll free) 1-888-EMI-GURU.

Public EMC Courses...

Here are the cities we have tentatively selected for the Fall 2006 EMC seminar series co-hosted by Tektronix and Kimmel Gerke Associates, Ltd. For more information, please visit our web site, *www.emiguru.com*.

Please note we have returned to a TWO DAY format. which includes PCB Design, Grounding, Shielding, Power, and Cables. We still cover the key design issues, but delete some systems issues. This was based on student feedback due to concerns about time out of the office.

-Denver, CO, Sept. 11-12 (Mon-Tue), 2006
Courtyard by Marriott , Louisville CO
-Seattle, WA, Sept. 18-19 (Mon-Tue), 2006
Carlton Inn at Totem Lake, Kirkland WA
-Minneapolis/St. Paul, MN, Oct. 3-4 (Tue-Wed), 2006
Courtyard by Marriott, Roseville MN
-Detroit, MI, Oct. 9-10 (Mon-Tue), 2006
Hotel Baronette, Novi MI
-Chicago, IL, Oct. 16-17 (Mon-Tue), 2006
Hampton Inn, Schaumburg IL
-Los Angeles, CA, Nov. 2-3 (Thu-Fri), 2006
Hacienda at LAX, El Segundo CA
-San Jose, CA, Nov. 8-9 (Wed-Thu), 2006
Courtyard by Marriott Airport, San Jose CA
-Phoenix, AZ, Nov. 13-14 (Mon-Tue), 2006
Windmill Suites, Chandler AZ

Please note that days of the week vary. By the way, four or more students from the same company qualify for a discount. All classes are conducted by either Bill or Daryl.

In-House EMC Courses...

Our on-site classes are as popular as ever, and we can tailor them for your specific needs—military, commercial, medical, automotive, industrial, telecomm, and more. We can address design, systems, and troubleshooting issues.

Most classes run two days, but some opt for a third day for more details. You supply the meeting space... we supply the materials and instructor (either Bill or Daryl.) Flat rate for up to 30 students, but even 10 students make sense.

IEEE Symposium on EMC...

August 14-18, 2006, at the Oregon Convention Center in Portland, OR. Hope to see many of you at the show!

Kimmel Gerke Bullets is a free newsletter on Electromagnetic Interference/Compatibility (EMI/EMC).
Published by Kimmel Gerke Associates, Ltd., 300 Christine Lane, W. St. Paul, MN 55118 • 1-888-EMI-GURU • http://www.emiguru.com

Focus on Signal Filters for EMC...

For many designers, "signal filtering" implies sophisticated multistage circuits with weird sounding names like Chebyshev or Butterworth. But for many EMI problems, even filters with only two or three components can very effective. In this article, we will take a quick look at the design and installation of simple EMI signal filters.

Filter Topologies – Most EMI signal filters are low pass devices, and are usually implemented in L, T, or Pi configurations. Series devices are resistors , inductors, or ferrites, while shunt devices are capacitors. Furthermore, the circuit impedance in most EMI applications have asymmetrical input and output impedance (not matched.)

Simple L configurations, either RC or LC, often provide adequate filtering. When using an L, the inductor or resistor should be pointed towards the lower impedance, such as a digital or analog driver. This takes advantage of the impedance mismatch already present between the driver and load circuits.

Slightly more sophisticated T and Pi configurations can provided additional attenuation. Since these configurations are symmetrical, you don't need to worry about which way they are installed. T filters are often preferred over Pi configurations for filters at I/O ports. First, they can protect the circuit ground by limiting currents injected on a signal pin from ESD or RF, and second, they degrade more "gracefully" with poor ground connections. Circuit board T filters are readily available in both through hole and surface mount configurations.

A word of caution. Pi configurations are popular for filtered connectors, with the shunt capacitors connected to the connector shell. If used, the shell MUST have a low impedance connection to the cabinet or circuit board. If not, the pi capacitors can allow noise currents to simply bypass the series impedance of the pi filter.

Component Selection – The components must be chosen to be effective at the frequency range you are trying to attenuate. We usually strive for shunt impedance values of a couple of ohms or less, and series impedance values of ten to hundred ohms or more.

For the shunt capacitors, this means values of 0.001 to 0.01 uf in the 100 MHz range, or values of 0.1 to 1 uF in the 1 MHz range. Incidentally, since human ESD events behave like 300 MHz RF events, we usually use 0.001 uF to 0.01 uf F capacitors for ESD filtering.

For the series components, we use inductors, resistors, or ferrties. Resistors can be used where DC voltage drops can be tolerated, with 100 ohms being a good starting point. Incidentally, RC filters have the advantage over LC filters of not ringing due to resonances.

For frequencies below 50 MHz, we often use small inductors ranging from 1uH to 100 uH. The smaller the inductor, the higher the self-resonant frequency, so the guideline is to "use enough, but not too much."

For frequencies above 50 MHz, we like to switch to EMI ferrites. First, ferrites minimize the capacitive "blowby" of wire wound inductors, and second, since ferrites are lossy at high frequencies, they minimize ringing. We usually strive for ferrties that provide at least 100 ohms at 100 MHz (a common parameter for EMI ferrites.)

Filter grounding – The choice of where to ground shunt capacitors depends on what grounds are available, and what your EMI goals are for the filter. Remember, you are simply diverting or steering high frequency currents. The simple question, then, is where to you want it to go?

For emissions, the best choice is to connect capacitors to the circuit board signal ground. After all, you are trying to keep high frequencies OFF cables, and ON the circuit board. The shunt connections need to be as short as possible to minimize unwanted inductance.

For immunity or susceptibility, the best choice is to connect capacitors to a chassis ground, thus diverting the current away from both signal and ground paths on the circuit boards. If an external chassis is not available, then consider adding series impedance in each line facing the outside world. This can be done with common mode chokes, or with T-filters on each signal and power line, augmented with ferrites on each signal return line.

Calculating filter attenuation – Here are some "Quick and Dirty" ways to estimate EMI signal filter attenuation at a given frequency. First, assume at least 20 dB of attenuation. This lets you replace all inductors and capacitors with resistors of equivalent impedance—phase is no longer a consideration. Second, ignore large shunt impedance (10X or more) or small series impedance (1/10 or less).

Under these conditions, the attenuation at a given frequency for a simple LC or RC filter in a digital circuit (low source impedance/high load impedance) becomes the ratio of the series and shunt impedance of the filter. For example, at 100 MHz, a 100 ohm ferrite shunted by a 0.001 uF capacitor (1.6 ohms) has a mismatch of 62, yielding a theoretical attenuation of 36 dB. The actual values will probably be a little less due to lead inductance.

A KGB Bullet...

Here is a good "rule of thumb" on transmission lines, from a well respected colleague, Dr. Howard Johnson:

if the line delay is less than one-sixth of the rise or fall time, and the source independence is no less than one third of the characteristic impedance (Zo), you will have very little trouble with ringing.

-From the Signal Integrity column in EDN Magazine.

Kimmel Gerke Associates, Ltd. Summer 2006

Where to locate a signal filter—Finally, is it better to place a filter right at a critical circuit, or is it better to place at an I/O port? Generally, for multilayer circuit boards, we like to place EMI signal filters at the I/O, as this helps prevent any unwanted coupling (such as crosstalk) between the circuit and the I/O port For two layer boards, however, we usually like to place EMI signal filters right at the circuit, since the circuit board already looks like a rat's nest of wiring for EMI purposes.

We hope this quick overview of EMI signal filtering has helped. For more details, check our *EMI Designer's Guide*, or join us at one of our newly revised EMC Design Seminars. As always, thanks for your interest and support!

Scientists dream about doing great things.
Engineers do them. *–James Michener, Author*

Engineering Humor...

A lawyer and an engineer were at a resort in Hawaii, and got to talking at the bar over mai-tais.

The lawyer said, "I'm here because my house burned down and everything I owned was destroyed by the fire. The insurance company paid for everything I lost."

The engineer replied, "What a coincidence! I'm here because my house and all my belongings were destroyed by a flood. My insurance company also paid for everything."

After a brief pause, the puzzled lawyer asked, "Just out of curiosity—how do you start a flood?"

E-mail vs. Snail Mail...

Most of you now receive the KGB by e-mail, which makes it easy for you to archive or forward (and which also saves a few trees and postage.) We do get quite a few returns, however, due to bad addresses or company firewalls.

As a fallback, we then send the KGB by snail mail. *If you want to receive the KGB by e-mail, please contact Bill at bkimmel@emiguru.com*—we will do the rest. By the way, our mail lists (both e-mail and snail mail) are PRIVATE, so you don't need to worry about spam from us.

Book Review... *Electromagnetic Compatibility - Second Edition,* by Clayton Paul, PhD.

This second edition of Dr. Paul's comprehensive and very readable treatise on EMC has been thoroughly updated, and now includes a CD. A valuable reference, and worth obtaining even if you already own the original edition.

Dr. Paul has authored twelve textbooks in EE, plus numerous technical papers—many dealing with EMC. He is an IEEE Fellow, and a Honorary Life Member of the IEEE EMC Society. ISBN 13:978-0-471-75500-5. Available from Wiley Interscience, 2006.

From the E-Mail Bag...

Here is a question we recently received., that may be of interest to others: *When testing for ESD, we have a lot of resets. Is this common? If so, why? And what can I do about it?*

Yes, resets are among the most common problems associated with ESD. This is not surprising when you look at an ESD event . With a nominal 1 nsec rise time, the resulting transients often look like a digital signal with a 1 nsec rise and fall time. Couple that with the fast response of most reset circuits, and false resets can easily occur.

The ESD energy can end up at the reset circuit through conduction (power/ground/signal), or alternately through electromagnetic radiation. The latter case is often referred to as "indirect ESD".

The best method to prevent or solve ESD problems is to harden any reset inputs right at the circuit level. A series ferrite or 100 ohm resistor and a shunt 1000 pF capacitor can work wonders. Sometimes the capacitor alone is sufficient, but you MUST keep the leads short.

If you are using an external "reset controller" or "power monitor" device, you may need some additional hardening. First, make sure the Vcc is decoupled right at the chip. Second, add ferrites and/or capacitors to any external reset lines. Third, try to keep the reset controller close to the processor to minimize pickup on interconnecting traces.. Fortunately, most modern reset devices now incorporate some Schmidt triggering to improve their noise margins.

If you can not harden at the circuit level, then you may need to filter entry points into the board or system. This includes both I/O and power inputs,. Once again, consider ferrite beads and 1000 pF capacitors. You may also need to install ferrites on "ground" lines to minimize any ground bounce from the ESD currents.

You may also need to shield your equipment against the transient fields that may couple directly on the board, past any filters. Such shielding is often mandatory when using one or two layer circuit boards. Thin materials are adequate (foil or even conductive coatings), but watch out for any openings over about 2 inches—including seams.

Finally, don't overlook software fixes for ESD. Assuming you have not changed states or lost any critical data, consider automatically restarting the system after an ESD event. For many EMC tests, "automatic recovery" is perfectly acceptable. You and your customers will surely appreciate that feature too.

A KGB Bullet...

Did you know that 74.3% of all statistics are made up???
–Jim Turley, EE Times, 01/06