KIMMEL GERKE Bullets

EMI GURU

Fall 2003/Winter 2004

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 60 Hz EMF. Although we have never discussed EMF in the KGB, we have worked on a number of EMF projects over the years. All were facility related, and ranged from office space with "wiggling" CRT displays to laboratory space with electron microscopes.

Projects included both prevention (site surveys) and troubleshooting (solving existing problems). Furthermore, we own a Holoday magnetic field meter, which has certainly facilitated our EMFefforts.

In this KGB, we'll share some insights based on our EMF experiences. As always, give us a call if we can help you with any of your EMI problems... EMF, military, commercial, medical, industrial, telecomm, avionics, automotive, and more...

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

Seasons Greetings...

Our sincere best wishes to you and your families this holiday season, and the best to you in 2004... *Daryl & Bill*

EMC Winter Workshops 2004
San Diego, CA – February 2-5, 2004
Orlando, FL – February 9-12, 2004

Need a winter break, and some fun in the sun ? Want to learn more about EMC design, systems, or trouble- shooting? Then join us in Orlando or San Diego in February for our "once a year" expanded seminar series. (This includes the *EMC Troubleshooting*, which we offer only at the Winter Workshops.)

Here are the class offerings:

— Two days on *EMC Grounding & Shielding*
— One day on *EMC & Signal Integrity in PCBs*
— One day on *EMC Troubleshooting*.

Take only what you need to get up to speed on EMC.

For more details, visit our website *(www.emiguru.com)* or call us toll free at 1-888-EMI-GURU.

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... August 9-13, 2004, at the Santa Clara Convention Center, Santa Clara, CA, USA.

Public EMC Courses...

Here are the cities selected for the Winter/Spring 2004 EMC seminar series sponsored by Tektronix and Kimmel Gerke Associates, Ltd. For more information, please visit t our website, *www.emiguru.com.*

– San Diego, CA - February 2-3-4-5, 2004
– Doubletree Club Hotel Circle, San Diego, CA
– Orlando, FL - February 9-10-11-12, 2004
– La Quinta Lakeside, Kississimme, FL
– Dallas, TX - March 2004
– Atlanta, GA - March 2004
– Washington, DC - April 2004
– Boston, MA - April 2004
– Newark, NJ - May 2004
– Rochester, NY - May 2004

By the way, four or more from the same company qualify for a 10% discount. All classes are conducted by either Bill or Daryl.

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)
-Medical Design for EMC (2 days)
-EMC in Telecommunications (2 days)
-EMC in Vehicular Electronics (2 days)
-EMC in Military Systems (2 ½ days)
-EMC in Avionics Systems (2 days)
-Design for ESD (1 day)
-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 "60 Hz EMF"...

We were wondering what to discuss in this KGB, and then a client inquiry provided an answer—power line magnetic fields (often referred to as "EMF"). Although we have not discussed this problem in detail before, we've dealt with quite a few EMF problems over the years. Sometimes elusive, they have all proved to be interesting.

Sources, paths, and victims... Let's begin with the classic model for EMI problems. The typical *sources* are power transformers, power wiring, and sneak current paths. The typical *victims* are CRT displays, electron microscopes, and occasionally even sensitive low impedance instrumentation. The *path*, of course, is electromagnetic radiation.

Sources... Unlike electric fields, which need only the presence of electrons (voltage), magnetic fields need actual movement of those electrons (current). Thus, the higher the current, the higher the magnetic field.

Paths... The magnetic field strength decreases as you move away from the source of current. For 60 Hz EMF, those levels decrease at different rates, depending on the source.

— For transformers, EMF amplitude decreases as the cube of the distance from the source.

— For balanced conductors, the amplitude decreases as the square of the distance from the source.

— For single conductors, the amplitude decreases inversely with distance from the source.

The good news is that for very high current sources (transformers and wiring), the fields drop rather quickly. Often moving a victim just a few feet can mitigate the problem. The bad news is that the slowly decreasing "single conductors" fields are often due to unintended sneak current paths that can be difficult to track down.

Victims... The most common EMF victims are "ballistic electron" devices, such as CRT displays or electron microscopes. A simple law of physics ($\mathbf{F}=q\mathbf{v}\times\mathbf{B}$) says that you can deflect a moving electron with a magnetic field.

For many computer CRTs, this can result in a "wiggling" display. Since many monitors use a vertical sweep of 70-75 Hz, superimposing an unwanted 60 Hz deflection on the electron beam results in a 10-15 Hz "heterodyne" that can be very annoying. Note that for CRTs used in televisions or older monochrome monitors, the vertical sweep is 60 Hz.

A KGB Bullet...

Here are some general guidelines we often use for "signal to return" lines in cables and connectors:

Risetime > 5 nsec - 5:1
Risetime = 3 nsec - 3:1
Risetime < 1 nsec - 1:1

Always keep critical lines (clocks, resets,etc.) next to a return line.

In that case, the heterodyne or "wiggling" does not occur. (Flat panel displays, which do not use an electron beam, are not bothered 60 Hz EMF.)

Electron microscopes, which rely on a highly precise electron beam, can also be affected by 60 Hz EMF. In that case, the beam is "smeared" which can adversely affect the resulting image.

Less common, but still possible, is interference to sensitive low impedance instrumentation, such as microphones or low level magnetic sensing devices.

Magnetic field units... Anyone who has had a physics class recalls the many different (and confusing) units for magnetic fields. These include Ampere/Turns per meter, Webers/square meter, Teslas, Gauss, and milliGauss. To further confound things, some of these are for "Magnetic Field" and others are for the "Magnetic Flux Density."

The preferred units for 60 EMF measurements are milliGauss, a measurement of magnetic flux density. One reason for this preference is that many calculations are simplified.

For example, the formula for a single conductor (often representing a sneak current on a conduit, water pipe, reinforcing bar, or even a metal building stud) is simply:

$$B=2I/d$$

where B is the magnetic flux density in milliGauss (mG), *I* is the current in amps, and *d* is the distance from the conductor in meters. Thus, a 10 amp current at 1 meter would result in 20 mG.

For reference, computer CRTs are often sensitive to EMF levels of 10-20 mG (or more), while electron microscopes can be upset by levels as low as 1 mG.

Mitigation techniques... Three common techniques for solving EMF problems are shielding, separation, and current reduction.

Shielding for low frequency EMF can be difficult and expensive. Permeable materials, such as steel or more exotic "mu-metals" are necessary. Nonferrous materials, such as aluminum foil or conductive coatings, are virtually transparent to 60 Hz magnetic fields. Special mu-metal shields are available for CRTs, but they can be pricy (its usually cheaper to buy a flat panel display). Shielding an entire room for 60 Hz EMF can be extremely expensive.

Physical separation is usually the preferred method. Here are some guidelines we have developed over the years:

— Overhead transmission/distribution lines - 100 feet

— Local transformers - 10-30 feet

— High current wiring/bus bars - 5-10 feet

Current reduction is usually not practical, although we did solve one facility problem by changing some heating loads (which reduced the associated 60 Hz currents.)
Field cancellation techniques are sometimes used as well.

EMF Health Concerns... No discussion of EMF would be complete without addressing this issue. Based on what we have seen and read over the years, we see no cause for concern. This is also based on the findings of scientific councils who have reviewed hundreds of EMF studies.

(Daryl keeps insisting, however, that EMF or EMI can make you go bald... but what does he know about that?)

Magnetic field surveys... This is probably the quickest way to identify an EMF source. Several years ago, we purchased a portable laboratory grade EMF meter that has proved quite useful for EMF surveys and troubleshooting. Without such a meter, finding the source can be very difficult. Once you identify the source, the solutions are often pretty obvious.

We hope you have found this discussion interesting and useful. Please call us if we can help you with any of your EMI needs — whether it is EMF, design, troubleshooting, or EMI training. You can call us at 1-888-EMI-GURU (toll free) or through our web site at *www.emiguru.com.*

> Age is a state of mind over matter. If you don't mind, it doesn't matter. — *Satchel Paige*

Application Note...

Since we first posted this notice, quite a few of you have requested 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 you need a copy, e-mail Daryl at *dgerke@emiguru.com.*

Some Engineering Humor...

Normal people believe that it it ain't broke, don't fix it. Engineers believe if it ain't broke, it still doesn't have enough features.

What is the difference between Electrical Engineers and Civil Engineers? EEs build weapons, and CEs build targets. (With apologies to Daryl's brother, a CE).

A minister, a doctor, and an engineer are waiting to play golf. The starter explains the foursome ahead of them is a group of blind firefighters, and the golf course allows them to play for free, even thought they slow up the course. The minister is touched, and says, "I will pray for them". The doctor is also touched, and says, "I have a doctor friend who might help them". The engineer is not touched, and asks, "Why can't they just play golf at night?"

Did you know???

Thanks to all of you who gave me feedback on my "Did you know???" comments in the last KGB. It turns out a bunch of the stuff was in error. I apologize — but I thought everything you read on the Internet was true!

Book Review...

High Speed Digital Systems Design - A Handbook of Interconnect Theory and Design Practices, by Stephen Hall, Garrett Hall, and James McCall. These three Intel Design Engineers share proven techniques and applications examples. Good practical information. ISBN 0-471-36090-2. IEEE Press/ Wiley Interscience, 2000.

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 the KGBs. We do get quite a few "returns", however, due to bad addresses or company firewalls. We then send the KGB by snail mail. *If you want to receive the KGB by e-mail, 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.

EMC Periodicals...

Here are some specialized publications on EMC that you may find of interest. (Several addresses have been updated since last mentioned in the KGB).

Compliance Engineering, Canon Communications, 11444 W. Olympic Blvd, Los Angeles, CA 90064, 310-445-4200. Annual Reference Guide plus quarterly updates. FREE. Visit *www.ce-mag.com*

Interference Technology (Formerly ITEM), R&B Enterprises, 3 Union Hill Road, West Conshohocken, PA 19428, 610-834-0400. Annual Reference Guide plus quarterly updates. FREE. Visit their web site at *www.interferencetechnology.com.*

Conformity, 531 King Street, Suite 6, Littleton, MA 01460, 978-486-0888. Annual Reference Guide plus quarterly updates. FREE. Visit *www.conformity.com.*

Electromagnetic News Report (ENR), Seven Mountains Scientific, PO Box 650, Boalsburg, PA 16827, 814-466-6559. Newsletter on EMC issues, with strong flavor on international regulatory issues. Bi-monthly. Subscription, about $70/year. Visit *www.7ms.com.*

IEEE Transactions on Electromagnetic Compatibility, IEEE. Monthly. Highly analytical. Subscription with IEEE EMC Society membership. Visit *www.emcs.org.*

KGB Newsletter, Kimmel Gerke Associates Ltd (You are reading it!!!) Highly authoritative newsletter by industry leaders. (No false modesty here...) FREE. Also available for download at *www.emiguru.com.*

EMI Suppression Handbook...

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 website at *www.7ms.com.*

How to Contact Us...

Telephone... Toll Free or Direct...
– Answering Service – 888-EMI-GURU (Toll Free)
– Bill Kimmel – 651-457-3715 (Minnesota Office)
– Daryl Gerke – 480-755-0080 (Arizona Office)

E-Mail... A preferred way of reaching us, if you don't need a "real time" answer. Addresses are:
– Bill Kimmel – *bkimmel@emiguru.com*
– Daryl Gerke – *dgerke@emiguru.com*

Snail Mail... If you need to mail or Fed-X something...
– Bill Kimmel, 300 Christine Lane, W. St. Paul, MN 55118
– Daryl Gerke, 2538 W. Monterey Ave., Mesa, AZ 85202

Web Site... Please visit our web site *(www.emiguru.com)* for class schedules, back issues of the KGB, etc. We've also included other detailed information on our firm.

EDN Magazine Designer's Guide to EMC...
The updated version of this popular guide (written entirely by Daryl and Bill) is still available from Cahner's Publishing Reprint Services.

Cost is $49.95. For information, or to order, go to our web site, *www.emiguru.com,* and click on the icon for the *EDN Magazine's Designer's Guide to EMC.*

EMI-Toolkit® 2.0...

Check out the updated version of our popular *EMI-Toolkit ®* software. The new 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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Kimmel Gerke Associates, Ltd.
300 Christine Lane
W. St. Paul, MN 55118

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