

KIMMEL GERKE



Bullets

Summer
2009

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

This KGB focuses on EMI with Global Positioning System (GPS) electronics. Thanks to inexpensive modules and chip sets, GPS electronics are being incorporated in a wide range of products and systems. These can range from cell phones to aircraft carriers.

We've seen several GPS/EMI problems in recent years. One involved potential intermodulation on a space satellite. Another involved a personal tracking system used by probation officers to confirm the location of their "clients." We've also addressed internal "self compatibility" problems within some consumer GPS systems.

Due to extremely low GPS signal levels, the EMI problems have been both interesting and challenging. We're also starting to see similar EMI issues in other wireless devices (perhaps a topic for a future KGB.) But regardless of your type of EMI problem, give us a call if you need help.

Best Regards

Daryl Gerke, PE, and Bill Kimmel, PE

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.html, 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 money (postage & printing) and some trees, and it lets you store them or forward them to your friends and colleagues. Thus, e-mail is our 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.

Shows and Conferences...

-- **IEEE Symposium on EMC**... August 17–21, 2009, at the Austin Convention Center in Austin, TX. We're both signed up to go, and hope to see many of you in the beautiful Texas "hill country."

Public EMC Courses...

Here are the cities we have selected for the Fall 2009 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.

- Portland, OR - September 14–15, 2009

Tektronix Campus - Beaverton, OR

- Chicago, IL - September 21–22, 2009

Holiday Inn Express - Downers Grove, IL

- Minneapolis, MN - October 1–2, 2009

Courtyard by Marriott - Roseville, MN

- San Jose, CA - November 2–3, 2009

Courtyard by Marriott - San Jose Airport

- Irvine, CA - November 9–10, 2009

Northwest EMC - Irvine, CA

- Phoenix, AZ - November 16–17, 2009

Freescale Semiconductor - Chandler, AZ

For more information, call 1-888-EMI-GURU, or visit our web site at www.emiguru.com. Please note you can also register on-line, and pay by Paypal. We have a 10% discount for four or more from the same company.

EDN Designer's Guide to EMC...

Written entirely by Kimmel Gerke Associates. First published as a supplement to EDN Magazine in 1994, and reprinted and updated in 2001 (three new chapters). We've been told this was one of EDN's most popular reprints.

This classic is now available — at a reduced price — directly from Kimmel Gerke Associates. Cost is only \$29 (includes US shipping). Call for special pricing on multiple copies. Attend a class and get a FREE copy of this book.

Watch us on "Web TV"...

Check out this great web site (espressoengineering.tv), created by Mike Violette of Washington Labs. Daryl is just one of many "reporters" on EMI/EMC issues. He spends about ten minutes discussing *EMI and Signal Integrity*. Not a full "fifteen minutes of fame," but close.

Focus on EMI in GPS Electronics...

Behold the "Law of Unintended Consequences." As you add new features and capabilities, unexpected things can happen. So it is with Global Positioning System (GPS) electronics and EMI/EMC.

We've seen several GPS/EMI problems in recent years, ranging from consumer to military electronics. Most of the problems have resulted in jamming the GPS receiver, but not damage. There have been reports, however, of lock-ups and damage at high RF levels, such as from radar.

Some GPS background... The GPS was developed by the US Air Force, and has been operational since 1995. It presently consists of 24 satellites (and some spares) in a medium earth orbit, nominally 20,000 km above the earth. Under normal conditions, 10 satellites should be in view at a time, but only four are needed for GPS operation.

Presently, GPS transmits on two frequencies: 1.57542 GHz (known as L1) and 1.2276 GHz (known as L2.) The L1 channel is for most applications, while the L2 channel is encrypted and thus reserved for military applications. The signals themselves are a bit complex, and are streamed at 50 bits/second, resulting in narrow bandwidth requirements.

Since these are satellite signals, the levels at the surface of the earth are quite low. Most GPS receivers need an input signal in the range of -120 to -140 dBm for satisfactory operation. Some new devices can detect signals as low as -160 dBm. Often these levels are below what can be seen on a spectrum analyzer, which can make sensitivity and EMI testing a bit challenging.

The GPS receiver needs two types of information. The first (known as ephemeris) provides reference information on satellite location. The second provides the timing data needed to calculate precise location. Since the ephemeris is only updated once every 30 seconds, it may take 30 seconds or more to "lock" onto the GPS. This is often referred to as TTFF, or "time to first fix."

Since the ephemeris signal contains more information, a stronger signal is usually required for initialization than for tracking. GPS receivers used in cell phones often use "assisted GPS", with the ephemeris data provided from the cell system. Thus, the cell phone can operate at lower signal levels than a fully independent GPS receiver.

A KGB Bullet...

In general, the clearance between a shield and the sides of a coil should be not less than the coil radius. Under such conditions, the shield will reduce the coil inductance by 10–20% in typical cases, while the coil Q will be reduced even less.

This applies to a nonmagnetic shield. A magnetic shield will slightly increase the inductance at the same distance.

— Dr. Frederick Terman, *Radio Engineering*, 1947

Ed. Note: Gotta love those old radio engineers...

EMI and GPS... Interference to GPS can be broadly categorized as unintentional and intentional. Both can pose serious problems.

Unintentional EMI includes both natural EMI (background "radio noise" and "space weather" such as ionospheric scintillation) and man made EMI (receiver desensing, often due to off-channel intentional RF transmissions, or jamming, due to lower level "unintentional" in-channel RF from nearby electronics.)

Due to the low GPS signal levels, it doesn't take much jam a receiver. A classic case occurred a few years back in the Moss Landing harbor (near Monterey CA) when a faulty preamplifier in an active TV antenna jammed shipboard GPS receivers throughout the harbor. This type of disruption would certainly not be acceptable for aircraft or other "life-safety" applications.

Don't overlook the possibility of intermodulation, if several other transmitters are collocated or used on the same platform. We once did an intermod prediction on a satellite, and a fifth-order product popped up near L1.

Intentional EMI is an increasing concern, particularly for the military, but also of concern for commercial applications. As already discussed, relatively low levels in-band L1 or L2 interference can render the GPS useless. Such GPS jammers are already readily available. We've read of cases where tracking systems on hijacked trucks were jammed with these devices.

Damage to GPS receivers can occur at high levels. One published research project showed that commercial receivers could be upset by pulsed radar signals at 500 V/m (Volts/meter); halted at 2 kV/m; and permanently damaged at 30 kV/m.

A variation on this theme is spoofing. A bit more sophisticated, a stronger GPS signal could capture a receiver and fool the receiver regarding actual location. Almost smacks of "Mission Impossible", doesn't it?

EMI Strategies... There are currently two approaches to EMI and GPS. The first is to identify, detect, avoid, and/or eliminate the sources of GPS interference. The second is to harden the GPS against interference, both low level and high level. It should be no surprise that much of the research is being sponsored by the military. After all, they have the most to lose in the battle of EMI versus GPS.

System Level Fixes— Here are some thoughts and recommendations at the system level. We've advocated these on military systems like space craft and robots.

—Pay attention to the GPS antenna location relative to other equipment and other antennas. Keep in mind that meeting radiated emissions (RE) requirements such as RE102 (MIL-STD-461E) may still not provide adequate protection.

—Pay attention to antenna cable routing. Even high quality coaxial cables leak in the GHz range. We saw this as a problem in a recent troubleshooting consultation.

—Pay attention to the other cables (power and signal) and the overall shield housing the GPS electronics.

Consider what we often call the “TV-tuner” approach, and pay attention to the critical sensitive electronics.

—Finally, in extreme cases, special directional antennas or DSP (digital signal processing) may be necessary.

Box Level Fixes - Here are some similar thoughts and recommendations at the box, or equipment level.

—Pay attention to the first RF stage, starting at the antenna input. These are probably the most critical nodes in the design. Good RF design, such as sophisticated band-pass filtering can help. For high level threats, transient protection may be needed.

—Shielding may be necessary — once again, think of the “TV tuner.” Commercial GPS modules are typically shielded, and make sense if you are not an RF designer.

—Choose clock frequencies that are NOT an exact sub-multiple of L1 or L2. Clock management at the board level is like spectrum management at the system level.

That’s it for this time. We hope you enjoyed our look at EMI and GPS. In the meantime, give us a call if we can help with any of your EMI issues — from DC to daylight.

A well adjusted person is one who makes the same mistake twice without getting nervous.
—Alexander Hamilton

A cost-saving idea on EMC training...

When times get tough, companies often cut training budgets. While we understand, we still think EMC training is a very good investment. Consider how much even ONE extra trip to the test lab costs. We have been told (many times) how our EMC classes saved money and improved designs.

One way to save money is to host a “joint class” with another company. As with a dedicated class, we can accommodate up to 30 attendees for a fixed price. You provide the meeting space, and we provide the instructor (either Bill Kimmel or Daryl Gerke) and the materials. All we ask is that you issue one purchase order (you divide the costs among the participants yourselves.)

We’ve had several companies use this approach with good success. It is particularly useful for smaller companies that might not fill a class, and those companies in locations we normally do not visit. The latter also saves on multiple travel costs — you only pay for one instructor’s travel.

As most of you know, we’ve been actively involved with EMC training for the past 20+ years, both with our public classes (co-hosted with Tektronix) and with our in-house classes. Between them, we’ve shared our “tools, tips, and techniques” for EMC success with several thousand of you.

We THANK YOU for your support and business!

Book Review...

Signal Integrity Simplified, by Dr. Eric Bogatin. Published by Prentice Hall, 2004. ISBN 0130669466. About \$80.

Easy to read, this book addresses signal integrity principles and problems in simple terms, but still contains plenty of details. Remember, what is good for Signal Integrity is usually good for EMC. Dr. Bogatin has a couple of other books you might find of interest as well, including his science fiction novel, *Shadow Engineer*.

From the mail bag...

Here is an e-mail question from one of our readers, and the answer we provided:

“I’ve designed a microcontroller that interfaces to a PC using a USB port. The board will be sold as-is for use by my customers either inside their own housing, or inside another piece of equipment. Do I need to test for the FCC requirements for EMC?”

If you were selling this as a stand-alone peripheral, you would be subject to both the FCC (US) and CE (Europe) EMC requirements. But since this is not a stand-alone system, you probably don’t need to do anything. The FCC/CE requirements apply at the full system level, and not at the subassembly level such as circuit boards.

To keep your customers happy, however, you might want to test board in a “typical” enclosure to demonstrate the requirements can be met. This is often done by IC manufacturers (particularly for peripherals such as Ethernet or USB devices), with the results published as an applications note. We’ve helped with several such *reference designs* over the years.

If you decide to do a reference design and test it, consider using an accredited EMC lab for the final test. You can do the tests yourself, but the accredited lab results might help with your marketing results. Good luck with your product!

Some Engineering Humor...

Need some cynical humor to keep you going? Try these...

- The light at the end of the tunnel has been turned off due to budget cuts.
- Rome did not create a great empire by having meetings — they did it by killing all those who opposed them.
- Pride, commitment, teamwork — words used to get you to work for free.
- If at first you don’t succeed, try management.

Websites to visit...

three of our favorites...

www.emiguru.com — Our website. Past issues of the KGB, bibliographies, useful tidbits, and more...

www.espressoengineering.tv — Video for engineers... served HOT. Great fun, we’re there...

www.interferencetechnology.com - EMI/EMC articles, buyer's guides, calendars, and more...



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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