KIMMEL GERKE Bullets

EMI GURU

Winter
2008/2009

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 EMC in Vehicles, or "Planes, Trains, and Automobiles" (not to be confused with the 1987 movie with Steve Martin and the late John Candy.) As it turns out, we've dealt with EMC issues in all three areas. While vehicular electronics share common problems, they often have their special concerns as well.

Vehicular electronics present some of the most challenging EMC problems we've seen. These systems typically incorporate multiple electronic technologies — analog, digital, and power — each with their own unique EMC issues. And of course, almost all vehicular systems have severe safety, reliability, and cost constraints. Never simple, but always interesting.

In the meantime, please give us a call if we can help you with any of your EMC issues — vehicular, military, medical, commercial, industrial, or ??? We're here to help.

Happy Holidays, and Best Wishes to all of you for 2009!

Daryl Gerke, PE, and Bill Kimmel, PE

EMC Winter Workshops 2009

Orlando, FL - February 3–4–5, 2009
San Diego, CA - February 10–11–12, 2009

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 trouble-shooting class is offered ONLY at these locations, as an optional extension to the two day class. If you have already attended a two day class, you are welcome to join us for this additional day.

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.)

Shows and Conferences...

— IEEE Symposium on EMC... August 17–21, 2009, at the Austin Convention Center in Austin, TX. Hope to see you in the beautiful Texas "hill country."

Public EMC Classes...

Here are the cities for the Winter/Spring 2009 schedule for the EMC seminar series co-hosted by Tektronix and Kimmel Gerke Associates, Ltd.

- **Orlando, FL - February 3-4-5, 2009**
  Best Western Lakeside, Kississimme, FL
- **San Diego, CA - February 10-11-12, 2009**
  Arrow Electronics Inc., San Diego, CA
- **Washington, DC - March 23-24, 2009**
  Washington Labs, Columbia, MD
- **Dallas, TX - March 30-31, 2009**
  Tektronix Region Office, Richardson, TX
- **Rochester, NY - April 28-29, 2009**
  Arrow Electronics Inc., Rochester NY
- **Boston, MA - May 5-6 , 2008**
  Arrow Electronics Inc., Boston MA

For more information on any of these locations, please visit our web site, *www.emiguru.com*.

Some thoughts on EMC training... We know times are tight, but EMC training is still a very good investment. Consider how much even ONE extra trip to the EMC test lab costs, and it just makes sense to prevent the problems in the first place. We'll give you and your colleagues the tools to *identify, prevent, and fix* EMC problems at the design stage, when the fixes are the most cost effective.

To further help, we've instituted a **NEW DISCOUNT PLAN**. For every student at full price, you can send another at half price. Over the years, we've seen companies benefit from sending multiple attendees to our classes.

For larger groups, (12 or more students,) it often makes sense to hold an in-house class. These are done at a fixed cost, with up to 30 attendees. This can really drop the cost per student. You can even co-share with another company — we've has several firms do this in the past.

Incidentally, all classes are conducted by either Bill or Daryl, so you get the benefit of our many years of dealing with EMC issues. We've already taught thousands the intricacies of EMC — put that experience to work for you.

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Focus on Vehicular EMI...

With all of the traveling we both do, we often have time to ponder EMI issues in our various modes of transportation. However, we try not to think too hard about the downside, particularly when flying through a thunderstorm or driving on an icy highway. At those times, we just hope our engineering colleagues have done their jobs to keep us safe.

Over the years, we've worked on many vehicular EMI problems. These include "planes, trains, and automobiles", along with "ships, submarines, and spacecraft." You can also include farm machinery, road building equipment, and even fire trucks and cement trucks. It's hard to travel anywhere, and not see some technology we've touched.

In this issue, we'll share some perspectives on vehicular EMI, and how to *best identify, prevent, and fix* these problems. We'll look at common issues along with the unique issues. Often the latter are the most challenging.

Common Issues... Almost all vehicular electronics are "embedded controllers." Unlike computers, which process data (accounting, word processing, cruising the Internet, etc.), vehicular systems are usually providing some function (engine control, brakes, HVAC, etc.). As such, overall speed is not a critical as simply getting the job done. Here are several common constraints.

Safety — Without a doubt, safety is the key constraint for any vehicular electronics. If you need to reset your PC, no big deal, but if you need to reset you anti-lock brakes, it may be too late. This means that vehicular electronics must not be vulnerable to environmental threats (RF, ESD, power disturbances). Any degradation should be graceful, with the ability to recover and continue if at all possible.

Reliability — Closely related to safety, many vehicular electronics systems are expected to last for years. We may throw a PC away long before a vehicular system wears out. Redundancy may be used to improve reliability — many aircraft systems employ dual or triple redundancy to assure safety and reliability.

Harsh Environments — Vehicular electronics are often placed in extremely harsh environments. These include extreme temperature and humidity ranges, shock and vibration, exposure to chemicals and even dirt. Many military environments pale by comparison.

A KGB Bullet...

Here are some conversion factors from electric field levels (Volts/meter, preferred by EMC engineers to pwoer density levels (milliWatts/cm^2, preferred by RF engineers).

Electric Field Levels	Power Density Levels
200 V/m	10 mW/cm^2
100 V/m	3 mW/cm^2
20 V/m	100 uW/cm^2
10 V/m	30 uW/cm^2
2 V/m	1 uW/cm^2
1 V/m	0.3 uW/cm^2

Unique issues... Although common in function, vehicular electronics often face additional special constraints. Here are some we've seen with "planes, trains & automobiles."

Planes — Two key EMC concerns for aircraft are lightning and RFI (radio frequency interference) to and from communications/navigation systems.

Without adequate protection, the lightning threat can be devastating. Fortunately, modern avionics are designed and tested to withstand this serious threat. This usually means serious hardening of I/O and power interfaces, as well as paying attention to grounding. A common "rule of thumb" is one lightning strike per year per aircraft.

The RFI threats are also serious, and can be both airborne and on the ground. Communications and navigation receivers are very sensitive, and onboard sensors often make avionics much more vulnerable to RF transmitters.

This usually means attention to shielding, and I/O filtering. Note that since many airframe manufacturers insist on using "pigtails" to terminate cable shields, the cables themselves are often inadequate at higher frequencies. Thus, additional I/O filtering is often mandatory.

Commercial avionics are typically tested to RTCA DO-160, or derivatives. Both the Boeing and Airbus EMC standards are based on DO-160, which in turn is similar to the military EMC standards for aircraft.

Trains — Some wag once said that trains are like planes, except they are closer to the ground. As such, they share similar constraints, such as RFI to/from radio transmitters and receivers. Power disturbances are another big concern.

We've had several consultations dealing with electronics in locomotives. Since VHF/UHF radios are ubiquitous and can get very close to the electronics, acceptable levels may be orders of magnitude below (emissions) or above (immunity) typical levels for commercial electronics. This usually means serious shielding design, with special attention to cables and I/O.

One interesting power threat is a "super load dump" that results in a huge transient on the power bus. One colleague who witnessed this said he though the locomotive had blown up. Of course, other power disturbances (such as EFT) can very nasty as well. All this means transient protection, filtering, and special attention to the power electronics design.

Another unique railroad EMC problem is "inductive coordination." Since railroads and power lines often share the same right-of-way, there is a potential for "crosstalk" between the power lines and the rails, which are used for railroad signaling. There are even special computer models to make these calculations.

European railroad electronics are subject to EN50121 and EN50155, which address the EMC environments at both

the full vehicle and electronics module levels. There are also proprietary standards, such as the "killer circuit" we once saw that was used to simulate the "super load dump."

Automobiles — Although automotive electronics face similar EMC threats, the biggest constraint is probably cost. While avionics or railroad electronic can probably afford to spend a few dollars on EMC, even pennies can pinch in the automotive world.

In addition to RFI and power disturbances, human ESD (electrostatic discharge) is a key automotive threat. Just sliding across the seat can generate significant charge, particularly on a cold, dry day. Getting out of the car can be even worse — there have been numerous fires started due to ESD discharges when fueling an automobile. As a result, most gas stations now warn you to touch the car before touching the fuel nozzle. We agree — good advice!

Automotive electronics are typically tested to individual manufacturer's EMC requirements, so they may vary. The standards, however, are generally derived from two SAE standards (SAE J1113 and SAE 551).

We hope you enjoyed our look at "planes, trains, and automobiles." And the next time you take a trip, thank your EMC colleagues for keeping us safe.

If you lend somebody $20 and never see them again, it was probably worth it. — Author Unknown

Sales & Marketing Experts...

A group of Sales and Marketing experts were given the assignment of measuring the height of a flagpole. Wearing suits and ties, they marched out to the flagpole with their ladders and tape measures, falling all over themselves to get an accurate reading.

An engineer comes along and sees what they're trying to do. He walks over, pulls the flagpole out of the ground, measures it from end to end, gives the measurement to one of the so-called experts, puts the pole back vertically into its slot in the ground, and walks away.

After the engineer has gone, the sales guy turns to the marketing guy and laughs, "Isn't that just like an engineer?" he says. "We're looking for the height, and he gives us the length."

Book Review...

R56 Standards and Guidelines for Communications Sites, by Motorola. Includes information on grounding, power, lightning, and more. Numerous contributors, including our friend and colleague, Don Backys, PE (K9UQN).

This 350 page manual is considered the industry bible for communications sites. We've used this document to assess site lightning protection along with general EMC concerns.

Available at *www.motorola.com*. $75.

From the mail bag...

Here is an interesting e-mail from one of our readers:

"We have a system with long cable runs (>500 feet). The cables are not continuous, and pass through several rooms with multiple steel bulkhead plates. The cables employ group shields that employ 360 degree terminations to the connector shells. Testing has shown this approach provides good protection for external EMI (emissions and susceptibility) from 10 kHz to over 4 GHz.

We still have a question on how to terminate internal shields over individual wire pairs. Should the internal shields be insulated from each other and carried through the connectors on pins, or should they be terminated to the connector shell that is also structure ground?"

The short answer is "it depends." Two key parameters to consider are the types of circuits, and their bandwidths.

For sensitive *low frequency circuits* (low level analog sensors, audio inputs, etc.), the preferred approach would be to insulate the shields from each other and carry the shield through connector pins. Furthermore, the internal shields should only be grounded at one end.

This approach minimizes the effects of the low frequency ground loop formed by the external group shield. This also provides some low frequency (<10 kHz) crosstalk protection. If additional crosstalk protection is needed, high frequency filters may be needed at the circuits level.

For *high frequency circuits* (digital I/O, Ethernet, etc.) the preferred approach would be to terminate the internal shields to the connector, using a short direct connection.

This approach should provide good high frequency protection against crosstalk. This would also increase the overall hardening for external radiated emissions and susceptibility. If ground loops are a concern with the digital circuits, they can often be addressed with optical isolators, fiber optics, or balanced circuits.

EMI-Toolkit(R) 2.0...

The updated version of our popular *EMI-Toolkit (R)* software 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 (R) Plus*. All the neat features of V2.0, plus additional information on most relevant EMC standards (MIL-STD-461, DO-160, FCC, CISPR)

For more information on either version, call us at 1-888-EMI-GURU, or e-mail *bkimmel@emiguru.com**

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Web Site... Please visit our web site (*www.emiguru.com*) for class schedules, back issues of the KGB, and other useful EMI stuff. We've also included detailed information on our firm, such as our consulting and training brochures.

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.*

In-House EMC Courses...

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

– Design for EMC (2 days)
– EMC Grounding & Shielding (2 days)
– EMC in Military Systems (2 ½ days – 3 days)
– EMC in Avionics Systems (2 days)
– EMC in Medical Devices (2 days)
– EMC in Vehicular Electronics (2 days)
– EMC and Signal Integrity in PCBs (1 day)
– EMC for Mechanical Engineers (1 day)

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