KIMMEL GERKE Bullets

MEMBER AMERICAN CONSULTING ENGINEERS COUNCIL

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Welcome to KGB. . .

And to our final issue for 1993. We hope this "personal communications" to our friends, clients, and colleagues helps you to *identify, prevent, and fix your EMI problems.*

This issue focuses on EMI Troubleshooting. We'll share some tips, techniques, and bits of philosophy on fixing EMI problems when you are under fire. Sooner or later, almost everyone will be faced with troubleshooting an EMI problem — we hope these insights are useful to you.

Thanks to all of you who returned the reader qualification cards for the KGB. We also appreciate the kind comments that so many of you added.

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

Winter Getaways. . .

If you haven't signed up for our "Winter Getaway" seminars in **Orlando** (Jan 31 - Feb 2) or **San Diego** (Feb. 7 - 9), there is still time. In addition to two days on EMI design, we'll also host an *optional third day workshop on EMI Troubleshooting.* Held in a round table format, we'll discuss how to identify and solve common EMI problems.

Here's a chance to learn more about EMI, plus enjoy some fun in the sun. (You must take the two day seminar to attend the troubleshooting workshop. If you have already taken one of our EMI seminars, call for special arrangements.) Fee is $750 for two days, or $1000 for all three days, which includes materials, lunches, and refreshments. Call for details.

These two seminars are part of our ongoing series sponsored by Tektronix. If you can't join us for these, watch for a regular two day seminar in your area.

Shows and Conferences. . .

Here are some shows and conferences in which we'll participate. Call if you want details on any of these.

Medical Design & Manufacturing West & East 94 Conferences. . .The "West Conference" will be held February 1 - 3, 1994, at the Anaheim Convention Center next to Disneyland, and the "East Conference" will be held May 23-26, 1994, at the Jacob Javits Convention Center in New York City. Both are sponsored by *Medical Device and Diagnostic Industry magazine.*

Daryl will present a tutorial on *"Designing for EMI/EMC in Medical Devices"* at both conferences. Bill will present a tutorial on *"Designing to Prevent ESD Upsets in Medical Electronics"* at the New York City conference. Our friend and colleague Dr. Bill Duff will also be presenting papers on medical EMI regulations at both shows. Come join us at these conferences if you design medical equipment.

Portable By Design Conference & Exhibition. . . February 14 - 18, 1994, at the Santa Clara Convention Center. Bill will be giving a one-day tutorial on *"EMI/EMC Design for Portability."* Fellow Minnesotan Eric Persson (Analog Circuit Design Inc.) will be giving a related session titled *"The Design & Implementation of DC/DC Converters for Battery Powered Applications."*

EMC/ESD International. . .April 12 - 15, 1994, which moves this year to Anaheim, California, after two years in Denver. This show is a favorite of ours, as it focuses on practical sessions. Great for the EMI newcomer. We'll be doing two sessions this year:

- *ESD Design Tutorial* (This is a repeat of last year's popular session.)
- *EMI Troubleshooting* (New Session)

Hope to see some of you there.

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Focus on Troubleshooting . . .

As consulting engineers, we spend a lot of our time troubleshooting EMI panics. In this issue of the KGB, we'll share some of our insights and ideas on EMI troubleshooting "in the trenches."

We see troubleshooting as a discipline separate from either testing or design. The goal of EMI *testing* is to *show compliance* with a test requirement. The goal of EMI *design* is to *prevent problems* with good design. The goal of EMI *troubleshooting* is to *isolate and fix* an existing EMI problem.

These different goals require different approaches. Just being a good EMI test engineer or designer does not make one a good EMI troubleshooter. Just like a doctor, it takes good diagnostic skills to get to the root cause of a problem. It also takes experience — not in testing or designing, but in troubleshooting — to develop and build those troubleshooting skills.

Here are some observations we've made over the years on EMI troubleshooting. We can't address everything in these few words, but perhaps we can share some key ideas we've learned.

Diagnose first . . . Too often, we see cases where fixes or tests are thrown at the problem without even looking at the possible causes. If your doctor gave you a prescription or recommended costly tests without reviewing your symptoms, you'd find another doctor right away! It's no different with "curing" EMI.

The first step is to gather as much background information as you can. What are the key symptoms? (Reset, loss of memory, display goes crazy. . .) When did the problem start? What are some potential environmental effects? (ESD? RFI? Power?) What are the constraints? (Cost? Packaging? Number of units to fix?) And don't forget ask the most important question . . . how will we know when it's fixed?

The second step is to sort through this information. It helps if you have a *diagnostic framework* to organize your data. We use the popular "Source-Path-Receptor" model, where we speculate on potential EMI causes, and how the unwanted EMI energy is coupled to potential receptor circuits. Next, we gather additional information on the "FAT-ID" parameters — Frequency, Amplitude, Time, Impedance, and Dimensions.

At this point, we often use a method the medical community calls *differential diagnosis.* The objective here is to rule out the least likely causes, as you try to match the symptoms to the "disease." For example, a sore stomach may just mean the flu, or it may mean appendicitis. But if appendicitis also means extreme tenderness and a fever, and you have neither, you can probably rule that out as a the likely cause of your discomfort. You may still be left with several other candidates, but at least you've narrowed the field.

Then try fixes . . . After an initial diagnosis, you are ready to "write a prescription." But don't just throw fixes or tests at the problem without thinking about the results. Predict what you think will happen, and then observe the results.

If your prediction is right and the problem gets better, you're a hero. If you completely solve the problem at this point, though, try to act humble, because it doesn't happen very often. We see about one "EMI miracle" a year, and we do this for a living. The rest of the time we just plug along and continue the battle.

If your prediction is wrong, don't fret about it. In fact, if you get the opposite of what you expect, that's almost as good as solving the problem. Just remove your fix, and try something in the "opposite" direction. This often happens when dealing with grounding or cable problems.

Try again . . . If nothing happens, try another fix. Don't remove the first fix, however, as you may need several fixes to resolve the problem. Many EMI problems are like a leaky boat — you won't stay dry until you plug *all* the holes in the boat. You can't get there if you only plug one "EMI-hole" at a time.

You are often playing the odds here. We had a medical doctor once offer the "Rule of 90 and 9." He explained that since medical diagnosis was not exact, you go with the most likely solution. If the odds are 90% in a given situation, you are "right" nine times out of ten. When you are "wrong," you just retrench and try again. In the engineering world, we often talk about "peeling the onion" as we encounter these multi-layered problems.

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A KGB Bullet . . .

The onset of saturation for a ferrite core or bead (Type 28/43) can be estimated by $I = 10\ ri$, and full saturation occurs when $I = 10\ ro$, where

I = net DC or peak line frequency current (amp-turns)
ri = inner radius (centimeters)
ro = outer radius (centimeters)

In practice, the core impedance drops rapidly due to saturation, but flattens out at about 25% of the non-saturated impedance levels.

Focus on Troubleshooting. . .

continued

Be bold. . .Two common problems we see are being too "scientific" and too "practical." In the first case, the concern is testing one variable at a time. In the second case, the concern is that certain fixes may be too expensive or impractical. Don't fall into these traps. At this point, you really want to know if the problem can even be solved. You can always go back later and remove things or optimize the solution.

In fact, try subtracting things. EMI problems are often solved by a process of isolation. Eliminate as many variables as you can (by powering down parts of a system or removing cables) and observe the results. In rare cases, you can even completely solve EMI problems by removing the offending parts. You'll never know unless you try.

Work from the outside in. . .When dealing with design problems we usually work from the inside out. We start with the circuit boards, and then proceed to the interconnect, power, shielding, and cables.

When dealing with troubleshooting problems, however, we usually reverse the direction. Cables and shielding are likely causes of field EMI failures, and they are easier to fix in the field. Focus on the areas where you have control, and can make changes.

Summary. . .We hope we've helped provide some insights on EMI troubleshooting. Although distinct from both EMI test and design, you can troubleshoot EMI problems with the right approach. And the more experience you get, the better you will be.

P.S. To learn more about EMI troubleshooting, join us at a Winter Getaway seminar.

Governments eventually do the right thing, after they've exhausted all other avenues.
Author Unknown

EMC EVENT Summary...

The 1993 Minnesota EMC EVENT is now history. The expanding slate of EMI related design and regulatory seminars were quite popular this year. Thanks to all of you who attended, and a special thanks to our exhibitors who make the show possible.

The IEEE EMC Society meeting in conjunction with the show was well attended. Dan McConnon of Banks Associates gave all of us an excellent overview of the EMF heath issue. Bill Kimmel was elected Chairman of the Twin Cities EMC Society Chapter.

EMI Design Seminars. . .

We've had very good reviews on our recent series of EMI design seminars sponsored by Tektronix. Designers tell us they like the emphasis on EMC solutions (design tips) rather than EMC problems (tests and regulations), and that we make our living solving EMI problems, not just teaching about them.

The Tektronix seminars are planned throughout the United States, so one will likely be coming your way. As a KGB reader, you'll get a special announcement about 4-6 weeks in advance of a seminar in your area.

We've also been providing in-house EMC training as well. We have several successful and proven formats, covering design, systems, grounding & shielding, etc. We can also custom tailor classes to your needs. For example, we've recently done several where we discussed the specific design (not test) impact of the new MIL-STD461D and IEC 801 regulations.

Book Reviews...

High Speed Digital Design by Howard Johnson and Martin Graham, Prentice Hall, 1993. This brand new book deals primarily with signal integrity on circuit boards and cables, with EMI as a secondary issue. Nevertheless, the design techniques are very applicable to EMI design. Lots of good information, formulas, etc. We like it and recommend it.

Controlling Radiated Emissions by Design by Michele Mardiguain, Van Nostrand, 1992. Once again, Michele shares his practical insights into EMI problems with a well written book on the subject. A good addition to his book on ESD. *(KGB Vol. I-4)*

A KGB Bullet. . .

Here are two rules of thumb for the susceptibility levels for power line disturbances:

(1) 100 volts peak impulse transients, both normal and common mode.

(2) 1 volt neutral-to-ground rms, common mode

From *"Grounds for Signal Referencing"* by Anthony N. St. John, San Diego Gas & Electric Company, *IEEE Spectrum*, June 1992.

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A New and Unique Concept in EMI Software

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Design Reviews

An increasing number of our clients now include ***EMC Design Reviews*** as part of their design process. They know that the earlier you address EMC issues, the more options you have, and the lower the costs.

A typical design review examines the *printed circuit board layout, interconnect schemes, power supplies, I/O cables & connectors, and mechanical packaging.* We can also advise on regulations and test strategies. Remember, test failures can cost you $20K+ in retest and rework at the end of a project.

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