

KIMMEL GERKE



Bullets

Winter
2013

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

This issue focuses on Printed Circuit Board Design Reviews. As EMC consulting engineers, we are often asked to conduct EMC design reviews. A key area of concern is the printed circuit board – critical circuits, stackup, trace routing, I/O protection, and more.

The goal is to catch problems early in the design stage, when it is inexpensive (or even free) to fix them. Knowing what to look for, you can do simple EMC design reviews yourself. You may not catch everything, but if you eliminate 90% of the problems, you are 10x (20 dB) better.

From circuit boards to systems, give us a call if you need EMI help. – *Daryl Gerke, PE, and Bill Kimmel, PE*

P.S. These comments are from a presentation at the 2012 IEEE EMC Symposium. As we have done with other talks, we can present this at your local EMC Chapter when we're in town for a class. (Already done it in AZ and MN.) For details, call us toll free at 1-888-EMI-GURU.

EMC Winter Workshops 2013 **Orlando, FL - February 18-19-20, 2013** **San Diego, CA - February 26-27-28, 2013**

Need a winter break, and some fun in the sun? Want to learn more about EMC design or troubleshooting? Then join us in Orlando or San Diego 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 troubleshooting 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.)

Celebrating 25 Years in Full Time Practice...

Monday, October 19, 1987, was the day we went full time with Kimmel Gerke Associates. It was also the same day the stock market crashed. Great timing!

No, we don't think we caused the market to crash – but it was a bit scary. Looking back, we now like to say, *"The first day in business was the worst day in business."*

It has been quite the adventure. We've worked on several hundred projects across a wide range of industries:

- *Computers* (microchips to supercomputers)
- *Military systems* (submarines to spacecraft)
- *Vehicles* (planes, trains, and automobiles... and more)
- *Medical devices* (many life critical - very rewarding)
- *Industrial controls* (factories to facilities)
- *Power generation* (including nuclear power plants)
- *And more...*

These projects have yielded several lifetimes of very interesting engineering experiences!

In addition, we have also trained over 10,000 engineers in EMC design through our public and in-house classes – sharing what we've learned with a new generation of engineers – a reward in itself.

So, **THANK YOU** to all of you who attended our classes or called us in to help with your EMI/EMC problems. Also, **THANK YOU** to our colleagues who encouraged us, and who graciously shared your knowledge and experiences. We sincerely appreciate all of you!

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 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 classic guide.*

Season's Greetings... Happy Holidays from our families to yours. Wishing you the peace and the joy of the season, and all the best in 2013!



Focus on Printed Circuit Board Design Reviews...

We've been conducting design reviews for years as part of our EMC consulting business. The goal is prevention (or at least early detection) of common EMI problems. Or as we're fond of saying, "An ounce of prevention is worth a pound of shielding."

When we last focused on discussed design reviews (2003) we discussed the full system – circuit boards, mechanical, power, and grounding. In this article, we'll focus on the circuit board alone.

This article grew out of a tutorial presentation at last year's EMC Symposium (2012). The tutorial itself grew out of a multi-year contract where we reviewed several dozen circuit boards for a defense client as part of their design process.

This client has had a very high success rate at the EMC lab with their circuit boards. They conduct multiple reviews at critical junctures (PDR, CDR, production release) and also address other non-EMC issues. Typically, the EMC issues only need a couple of hours, so it was time well spent.

As the reviews progressed, a formal check list evolved. Ten points, divided into three sections, as follows:

- Schematic review (circuits)
- Board construction review (stackup, splits, etc.)
- Periphery review (I/O, power, grounding)

After the review, we documented the findings in a memo.

You can do this too, often in an hour or two. But keep it simple. Grab a buddy – two sets of eyes are better than one. If you want extra help, we can support you for a nominal fee with a conference call and a document pre-review. We can also provide brief a written summary.

But first, three general tasks before you start.

- *Identify key threats* - emissions, RF, ESD, power disturbances (ESD/Lightning), and self-compatibility
- *Identify key circuits* - digital, analog, power, I/O
- *Identify key constraints* - environment, cost, weight, space, power, and special concerns (leakage currents, etc.)

Keep in mind that applicable regulations may not be adequate for harsh environments, and don't forget to include the *cost-of-failure*. (Particularly safety issues.)

KGB Bullet... New Public Class
EMI/EMC in Military Systems
(Includes MIL-STD-461/464 & Troubleshooting)

When: April 9-10-11, 2012

Where: Columbia, MD (Exact location TBD)

Cost: \$1495, discount for 4 or more

Registration: ATCourses.com (Our cosponsor)

Contact us for more details at 888-EMI-GURU

Here are ten key points to check on your circuit boards:

(1) *Clock Circuits* - Primary sources of high frequency emissions. Also clock-like circuits that are highly repetitive.

Check - High frequency decoupling at Vcc. (Series ferrites provide even more protection.) Series resistors in clock outputs (10-33 Ohms typical.) Crystals or resonators located next to the oscillator.

(2) *Reset/Interrupt/Control Circuits* - Resets are very vulnerable to ESD, EFT, and transients. Interrupts and control (Read/Write) are also vulnerable. Lines to mechanical switches (external resets) extremely vulnerable.

Check - High frequency decoupling of Reset Vcc, reference, and output s with trace lengths over two inches of trace length. (Series ferrites for additional protection). Similar fixes as needed for interrupt/control circuits.

(3) *Analog Circuits* - Very vulnerable to RF. Parasitic oscillations may cause unwanted radiated emissions.

Check - High frequency decoupling of Vcc. High frequency filtering of both inputs and outputs at circuit. Similar protection also needed directly at sensors.

(4) *Voltage Regulators* - Vulnerable to RF. Parasitic oscillations common in VHF/UHF frequency ranges.

Check - High frequency decoupling (1000 pF typical) directly at input and output pins to chip neutral pin. This is highly recommended to prevent oscillations.

(5) *RF Transmitters & Receivers* - Onboard receivers jammed by digital and other noise. (GPS extremely vulnerable.) On board transmitters jam analog circuits.

Check - Protect receiver inputs (may need special design.) Internal shielding of RF modules. Clock management (avoid harmonic.) Antenna location and cable routing. DSP or other software techniques.

(6) *Board Stackup* - Good board construction critical for good EMI control. Fortunately, most fixes are free.

Check - Keep every signal layer next to an adjacent plane. Keep respective power/ground planes adjacent. Maintain a symmetrical stackup. Consider outer buried planes.

(7) *Split planes* - Traces crossing cuts and mismatched planes can seriously negate EMI controls on the board.

Check - High speed traces crossing cuts and "over and back" traces across cuts. Low speed traces across cuts can cause problems too and should be eliminated. Always align the power/ground planes as a mirror image.

(8) *Floor Planning & Routing* - Random placing of components, and random trace routing.

Check - Segregate components according to frequency. Pay attention to critical traces (clocks, resets, control lines.) Avoid placing critical circuits near I/O ports. Separate high/low speed traces, and digital/analog/power traces. Manually route critical traces when possible.



(9) *Protect the Periphery* - Since power and I/O connect to the outside world, they need special attention.

Check - Filters and transient protection as needed. As a minimum, 0.01 uF capacitors across all power inputs. Pay attention to ESD protection on external I/O lines.

(10) *Grounding* - Often confusing with requirements that seem to conflict.

Check - Multi-point ground connections for high speed digital (and RF) circuits. Single point connections for low level/low frequency analog circuits. Hybrid grounds (caps and inductors) for mixed technologies. Note that in harsh environments, additional grounding constraints may apply.

So there you have it – our ten point check list for printed circuit board design reviews. Hope you found this useful. Give us a call if you need EMI help, from circuits to systems, and from designs to disasters.

Visit www.emiguru.com ... As we continue to update and improve our on-line collection. Coming soon:

- Library of past articles and papers
- Searchable vendor data base (including test labs)

Our web site already contains the following FREE stuff:

- All the past KGBs (20 years worth)
- EMC bibliography of recommended books, periodicals, and useful web sites.
- UBI (Useful Bits of Information)
- Espresso Engineering videos with both Bill & Daryl
- EE-Web Magazine interviews with both Bill & Daryl
- Class locations and registration info.

Why most projects take twice as long as expected...

- The first 90% of a project is spent making things work.
- The second 90% is spent making sure things don't break - including EMI problems.

– Bill Kimmel, PE

About the KGB... A year ago we debated about going all electronic on the KGB, but then decided to retain the printed version. For now, we have compromised with an annual printed version.

With the majority of our readers now on our electronic list, we may eventually go all electronic. So, if you are still getting this by snail-mail we invite you to sign up for the electronic version on our web site. *Thanks – save a tree !*

BTW, our mail lists are private. No spam, and we won't rent or sell your name. You will hear from us, however, about classes, webinars, or our latest newsletter.

Some Comments on EMC Training...

You may have noticed our public class schedule has shrunk in the past year or two. We've even had several inquiries regarding specific upcoming classes. We sincerely appreciate your interest and concerns!

Due to the economy, revenues have been down as companies tighten training and travel budgets. At the same time, the expenses (promotion, hotels, catering, etc.) continue to increase. Thus, we've had to cut back too. While we enjoy the teaching, we still run a business, and our classes must carry their own weight.

NO, we are NOT getting out of the training business! We remain as committed as ever to helping our clients through our public and in-house EMC classes. At the same time, we won't be doing this forever. After all, we just celebrated 25 years in full-time practice. We also just celebrated 20 years of our *Design for EMC* classes.

Not to sound immodest, but we're at the top of our game. As such, it is a great time for you to tap into almost a century of our collective EMI/EMC experience. After all, the problems are not going away anytime soon.

If you can't join us at a public class, here are some alternatives. All have been used in the past with success.

– *In-house class.* The break-even is about 12 students (less if you must travel). We train up to 30 students at a fixed fee (no per-seat fees). You provide the training space, A/V, and refreshments. We provide the materials and instructor.

An added advantage is that we can tailor material to focus on your particular problems. We can also add design reviews. BTW, our in-house classes continue to do well.

– *Hybrid class.* Share an in-house class with another local company or two. Similar to an in-house class, but we just request one invoice (you work out the money split.)

– *Educational grants.* Many states have training grants. We've done a couple of classes this way. One was a dedicated in-house class. Two more were co-sponsored by a test lab and a local college as a way to serve their local technical community. The money is often available.

The payback for EMC training is certainly there. Save one trip to the test lab, and you have recovered the class fees. Any savings after that are 100% profit.

But it is not just test savings. One client told us that preventing just one equipment shutdown saved \$50K. Another client told us that getting to market one month early was - as the credit card people say - *priceless!*

We hope this has stimulated your thinking about some viable EMC training options. Call if you want to explore them (888-EMI-GURU.) In the meantime, you can find our latest public class schedules at www.emiguru.com.

Kimmel Gerke Associates, Ltd.

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New Partner for Systems Classes...

We are pleased to announce a new training partnership for our EMC Systems classes. The training company is the Applied Technology Institute, a firm that specializes in the military/defense training market. As such, we were invited to add our *EMC in Military Systems* to their catalog.

The first public offering of this class is scheduled for April 9-10-11, 2013 in Columbia MD. The class focus is at the systems level (power, grounding, cables, shielding) and does NOT address printed circuit boards. It does address MIL-STD-461/464 and EMI Troubleshooting. Register at www.atcourses.com or www.emiguru.com.

This has no effect on our partnership with Tektronix and the popular *Design for EMC/Signal Integrity* series. While recent schedules have been limited due to the economy, we very much enjoy working with our Tektronix colleagues.

Daryl has moved... But only about a mile away. Downsized to a patio home. Here is the new address:

*Daryl Gerke, PE
Kimmel Gerke Associates, Ltd.
2256 W. Lindner Avenue #31
Mesa, AZ 85202*

Phone numbers and e-mail address are the same.

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-Ex something...

- Bill Kimmel, 628 LeVander Way, So. St. Paul, MN 55075
- Daryl Gerke, 2256 W. Lindner Ave. #31, Mesa, AZ 85202

Web Site... Please visit our web site (www.emiguru.com) for class schedules, back issues of the KGB, etc. Also includes details on our consulting & training services.

KIMMEL GERKE ASSOCIATES, LTD.
EMC Consulting Engineers

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