KIMMEL GERKE Bullets

Summer, 1997

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 discusses EMI in power supplies. In the past, most power supply EMI problems were conducted emissions. Recently, however, we've been seeing an increase in radiated emissions problems from power supplies, plus immunity problems with RF and ESD. In this issue, we'll take a quick look at some of the power supply EMI problems we are running into these days.

Fortunately, most power supply designers are sensitive to these problems. But some of these problems are quite subtle, so even an off the shelf supply may still hold some EMI surprises. If you are designing your own supply, maybe we can help you avoid some of the more common EMI problems you might encounter.

As always, give us a call if we can help you out with any of your EMI problems — from lowly power supplies to full systems.

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

P.S. Thanks to all of you for your support and confidence in us over the years. 1997 is our ***Tenth Anniversary*** *in business as full time EMC consulting engineers. It has been a sincere pleasure working with so many of you.*

Please Requalify

Please return the enclosed card if you wish to continue to receive Kimmel Gerke Bullets. If you joined us or updated in the last few months, you can disregard this request. If in doubt, send in the card and we'll make sure you stay on our mail list.

Since many businesses no longer deliver bulk mail, feel free to use your home address. Besides, if you change companies, you'll still receive the KGB. By the way, our mail list is PRIVATE... it is never used by anyone else.

Shows and Conferences...

Here are some shows and conferences that may be of interest. Call us if you'd like more details.

IEEE EMC Symposium... *August 18-22, 1997, at the Austin Convention Center in Austin, TX. Daryl will be presenting a session on "EMC Design in Power Supplies," also the topic of this issue of the KGB. Hope to see many of you in Austin, enjoying some of that famous Texas hospitality. Y'all come now, hear?*

Portable by Design... *September 17, 1997, at the Burlington Mariott in Burlington, MA. This is part of the Microwave and RF show sponsored by Electronic Design Magazine. Bill will be doing a one day seminar on EMC design issues relevant to portable products.*

1998 EMI Winter Getaway... *Even though it's the middle of summer, we're already planning for our special Design for EMC seminars with the optional EMC Troubleshooting session. Planned for February, one will be in Orlando, and one will be in Phoenix. Need a winter break with some sunshine? Come join us.*

Thirteenth Annual Minnesota EMC Event... *Back by popular demand in April 1998 at the Thunderbird Hotel in Bloomington, MN. More details in the next KGB.*

EMC Seminars...

We're closing in on five years with Tektronix as the sponsor of our popular ***Design For EMC*** *seminars. Past attendees tell us they really like our emphasis on practical EMC solutions (design tips & techniques). After five years, the presentation is well polished and full of punch. (It's fresh too... we update it at least twice a year, based on the "real-world" problems we see as full time EMC consulting engineers.)*

Design for EMC *is also available in-house, and has been very popular. (If you have 12 or more, it becomes quite cost effective.) We also offer other in-house classes, such as* ***Grounding & Shielding, Medical Design for EMC*** *and more. Based on client inputs, we are also considering a one day class on* ***Understanding EMC Regulations.*** *Call 1-888-EMI-GURU if you are interested in any of these seminars... public or private. (Public classes offered in a wide range of cities throughout the year.)*

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Focus on Power Supply EMI...

While power supplies are not high on most "EMI lists of concerns", we've seen an increase in power supply EMI problems. In addition to the expected conducted emission problems, we've been seeing radiated emissions problems, as well as immunity problems with power supplies. In this KGB, we'll take a quick look at these emerging problems, and how to identify, prevent, and fix them.

Power supplies can act as sources, paths, and victims of EMI, which can add to the confusion. Switching mode circuits are obvious sources, but other secondary sources include diode recovery noise and parasitic oscillations. Power supplies can provide unexpected paths through the supply (particularly for high frequencies) due to effects like parasitic capacitance in transformers or parasitic inductance in filter capacitors. Finally, power supplies can be victims, to all kinds of input power disturbances (sags, surges, transients, RF energy, etc.) Let's examine some of these problems in more detail.

Conducted emissions - It's no surprise that this is a major EMC problem with power supplies, particularly switchers. After all, every switcher contains a high power oscillator that generates not only a strong fundamental frequency, but lots of harmonics as well. Other sources include pulses due to flyback circuitry and diode recovery.

A special problem common with switchers is parasitic coupling from the switching transistors to heat sinks, which result in coupling to the chassis with a "common mode" return through the "hot" and "neutral" input power leads. Two variations on this problem are capacitive coupling through the transformer, or even capacitive coupling from the traces/wiring to the power supply chassis.

The solutions to these conducted emissions problems include input power line EMI filters (they must provide both "differential mode" and "common mode" filtering), diode "snubbers", Faraday shields between switching transistors and heat sinks, Faraday shields in transformers, "scavenger" capacitors between input and output, and careful attention to circuit/trace layout.

Power line harmonics - This is a recently emerging problem that has gained new credence due to European Union regulations that become mandatory in 1998 (IEC 1000-3-2). The primary concerns are the first 40 harmonics of the power supply input, so these represent "low frequency" emissions under a couple of kilohertz.

Power harmonics from power supplies are a result of the "non-linear" input presented by diodes rectifying off the mains, and then charging a capacitor. Since the current is consumed only at peak voltages (to recharge capacitors) rather than over the entire 50/60 Hz sine wave, current harmonics are generated (remember the Fourier series). While these harmonics usually don't cause problems for electronic equipment, they can severely stress the power distribution system, causing heat losses in transformers, motors, and even neutral wiring.

These problems are best solved in the power supply design. Solutions include "pre-regulators" and special transformer configurations to smooth out the harmonic currents. If you are buying power supplies for products destined for Europe, be sure to ask your vendor about harmonic compliance. (By the way, DO NOT assume the "CE" mark assures this, since harmonics are not mandatory until 1998.)

Conducted immunity - Since most power supplies are connected to an outside power source, they have been dealing with these problems for years. Common problems include transients, voltage sags and surges, and even complete power outages. Often referred to as "power quality", the Europeans are still working on regulating this, with a large number of impending specifications in the wings (IEC 1000-3-6 through 12 or more). In the meantime, we think that the IEEE "Emerald Book" (IEEE-1100-1992) is a good resource for these problems.

Two major transients of concern today are the "electrical fast transient" (EFT) and the "surge". Both are included in today's European tests as IEC 1000-4-4 and 4-5. The EFT simulates a "showering arc" with 5 nsec edges, while the "surge" simulates a lightning hit with lots of energy. Both require special design precautions.

Incidentally, if you are working on vehicular electronics (auto, truck, railroad, avionics), there are special transient and power requirements that apply. The objective is to match the equipment to the anticipated environment. Many of these vehicular transients are much worse than those on AC mains.

Solutions include input transient protection, filtering, and attention to power supply regulation and energy storage. By the way, due to the high frequency nature of the EFT (5 nsec behaves like 60 MHz), we've found that multi-turn ferrites are often effective against this threat.

Radiated emissions & immunity - In the past, most power supplies have not been a factor in either radiated emissions or immunity, particularly above 30 MHz. That situation has definitely changed, as we have seen an increasing number of "high frequency" problems with power supplies in the past few years. These often result in "weird" EMI problems. (We recently saw an emissions problem at about 200 MHz due to parasitic oscillation between two parallel diodes.)

Many of these problems are due to faster silicon, from switching transistors to IC regulators. As switching edge rates decease, high frequency emissions can increase. At the same time, "faster" regulators are now vulnerable to RF and high speed transients like EFT and ESD.

The solutions for these problems are to add high frequency decoupling, filtering, and snubbing components. We regularly recommend 0.001 uf capacitors at all voltage regulator inputs and outputs to minimize both RF susceptibility and parasitic RF emissions. We also often recommend small caps and/or ferrites on switching transistors to control high frequency harmonics. (By the way, we're usually only taking out a few nanoseconds, so the effects on efficiency are minuscule.) Finally, we like to see high frequency filtering at the inputs and outputs on power supply modules.

We hope this has given you some ideas and insights on EMI problems with the "lowly" but very important power supply.

A KGB BULLET...

Rules of thumb and misapplied formulas have resulted in many designers puzzled over the correct value of decoupling capacitors to use on their circuit boards. A study by Vince Greb (EMC Integrity) and Charles Grasso (Storage Technology) showed that for a wide range of loads and frequencies that one capacitance value — 0.01 uf — provided adequate decoupling for today's typical designs.
(See EDN Magazine, September 1995, for details.)

Past KGBs...

Some of you have asked about our newsletter, concerned that you may have been dropped from our mail list. We apologize, as we've fallen a bit behind this last year with the KGBs. Between Daryl's move to Arizona, and our heavy work loads (see Extra EMC Help, page 4), we've been a bit snowed under.

Our first goal, of course, is to help our clients through our consulting and training, so some of our publishing efforts have slipped. Thanks for your concerns, and your patience.

By the way, be sure to requalify (return the enclosed postcard) if you want to continue to receive the KGB. You can also requalify by EMail(bkimmel @ emiguru.com)

A KGB Bullet...

Here are some "info-bullets" on the world wide web, given to us by two technical publishing colleagues:

www.edtn.com - Electronic Design & Technology Network, an experiment in collaborative publishing. Thanks to Jack Schandle, Editor (and former editor of Electronic Design magazine.).

www.std.com/~techbook/compliance_faq.html - Links to the FAQ page of sci.engr.electrical.compliance. Thanks Martin Rowe, Editor of Test & Measurement World.

Electronic Communications...

Here is a quick summary of several ways of contacting us or getting information:

World Wide Web — Visit our "home page" at **http://www.emiguru.com.** You'll find back issues of the KGB (Kimmel Gerke Bullets), plus an assortment of other EMC related information. Please feel free to pass the address along to others who might be interested.

Toll Free "888" Number... Please feel free to call us on our toll free number **1-888-EMI-GURU** (1-888-364-4878). This reaches our answering service in St. Paul, Minnesota, so please leave a message and we'll get back to you. For calls from outside the US, you should continue to use 612-330-3728.

E-Mail... A preferred way of reaching us if you don't need a "real-time" answer. We both check our mail boxes regularly, and it works out well. Addresses are:
Bill Kimmel - bkimmel@emiguru.com
Daryl Gerke - dgerke@aol.com
(Please note that Daryl finally gave up on AOL, so please send E-MAIL to his NEW ADDRESS.)

> "Show me somebody who is always smiling, always cheerful, always optimistic, and I will show you somebody who hasn't the faintest idea of what the heck is going on." – The late Mike Royko of the *Chicago Tribune*

Is ESD Destructive, or what?

Bill Kimmel reports a new personal high for destroying chips while troubleshooting ESD. Working with clients Ken Stapelton and Phil Kamin of K-Phil Manufacturing in St. Catherine, Ontario, Bill smoked 20 microprocessors in the process of running down an ESD problem on a two sided board. The only repeatable symptom of upset was a hard failure. Ultimately, the problem was solved with the aid of a ground plane.

This brings into focus the two messages we continually pass along to our clients. First, it is almost impossible to stop ESD once it gets on a two sided board. Second, have plenty of spare parts available when troubleshooting ESD problems.

To you gamblers, K-Phil has just introduced a high speed pull tab dispenser that can dispense up to 100 tickets in less than ten seconds. There is no truth to the rumor that their next model will reach into your pocket for your wallet. (Thanks Ken and Phil.)

Book Review...

Digital Design for Interference Specifications (Second Edition), by David Terrell and R. Kenneth Keenan. This is an update of an earlier text (1983) by Dr. Keenan. The second edition (1997) is well done, and contains a lot of solid, practical information. ISBN 0-945049-02-1. Published by the Keenan Corporation, (813-544-2594) Tampa, FL.