KIMMEL GERKE Bullets

MEMBER AMERICAN CONSULTING ENGINEERS COUNCIL

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Welcome to KGB. . .

And to the twelfth issue of our "personal communications" to our friends, clients, and colleagues. We hope you find this useful , and that it helps you to **identify, prevent, or fix your EMI/EMC problems.**

This issue focuses on analog circuits, and their special interference design issues. Analog design is often considered as esoteric as EMI design—put the two together, and it really gets interesting. But like most EMI problems, once you understand a few key issues, analog EMI problems become manageable.

We've worked on a number of analog projects, from simple microcontrollers with analog circuits to very sensitive and sophisticated measurement equipment. Threats ranged from low level 60 Hz electric and magnetic fields to high level RF in the 100 MHz-1 GHz range, as well as ESD and power disturbances.

As always, give us a call if we can help you with any of your EMI problems, analog or otherwise.

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

MINNESOTA EMC EVENT

Plan now to attend the *Seventh Minnesota EMC Event,* sponsored by Kimmel Gerke Associates and AMADOR. . . Learn about EMI, ESD, Power Quality, new EMC regulations. . . *October 20-21-22 at the Thunderbird in Bloomington, MN,* next to the Mall of America.

SEMINARS

Design for EMC. . . Industrial and Systems EMC. . . Product Safety. . . EC and FCC Updates. . . Telecom. . .

TRADE SHOW DISPLAYS

Visit over 35 exhibitors on October 22, representing a wide range nationally known EMI products and services.

TUTORIALS

Attend free half-hour tutorial sessions October 22, all through the day. *Lot's of new EMI information.*

CALL KIM AT 612-465-3911 FOR MORE DETAILS

Shows and Conferences. . .

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

IEEE 1992 EMC Symposium. . . August 17-21 in Anaheim, California. Technical sessions, plus three days of exhibits. Daryl will present a paper titled *"Electric Field Levels Around A Typical Amateur Radio Station."* Hope to see you there.

Seventh Annual Minnesota EMC Event. . . October 20-21-22 at the Thunderbird Hotel in Bloomington, MN. Part of EMC-WEEK-1992. Activities include in-depth seminars (Oct. 20-21) and the free trade show and tutorials (Oct. 22.)

Also planned is a special joint meeting between the IEEE EMC Society and IEEE Power Engineering Society (Oct. 20) to discuss Power Line Harmonics.

EMC/ESD International. . . April 28-30, 1993 in Denver, CO. This is an encore of last year's well managed and well attended show sponsored by *EMC Test and Design Magazine.* If you didn't make it in 1992, be sure to go in 1993. A great show for both the newcomer and the EMI pro.

Thanks for your Postcards. . .

Thanks to all of you who returned the post cards from the last issue of the KGB. We've updated our list, and should now have your correct addresses.

Thanks also for your comments. . . you've given us enough good ideas to keep us in publishing material for the next five years. Unfortunately, some of those ideas would take more space than we have in the KGB. But your suggestions are noted, and we hope to get some of them printed as magazine articles. We'll keep you posted.

If any of your colleagues would like to receive the *KGB*, just give us a call at 612-330-3728.

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Focus on Analog Circuits. . .

While many systems today are primarily digital, analog still plays an important role in electronics. Here are some comments and observations on the special EMI problems that occur in analog circuits, devices, and systems.

EMI problems in analog circuits are aggravated by several factors. These often include **low signal levels, high impedances, and low frequencies.** Plus many analog systems, such as instruments, must work in very **harsh environments,** which just adds to the EMI problems.

The **classic analog threat is 50/60 Hz interference** due to electric or magnetic fields, or noise coupling due to the infamous *ground loops.* The combination of low levels and high impedances is a killer here, and low operating frequencies often precludes filtering unwanted 50/60 Hz signals.

New EMI threats have begun to plague analog systems as well. These include RFI from nearby radio transmitters or sags/surges on power lines. Internal jamming from high speed digital circuits has also become a problem, as more and more analog systems incorporate microprocessors and computers.

RF interference is particularly vexing. Low level stages can be driven into saturation, turning that stage into a detector. Any modulation is then demodulated and passed along to subsequent stages. This effect is know as *audio rectification,* and it explains why you can hear the voices from a 27 MHz CB radio on a 20 kHz audio amplifier. You *must* block the RF (with power decoupling and high frequency filters) *before* it reaches the sensitive circuits.

Power sags and surges can also be sneaky. Slow sags or surges can modulate sensitive low level stages. Digital current pulses can also cause the same problem. That's why separate well regulated power supplies are so important in analog applications.

The good news is that most analog circuits are not prone to upset from spikes, such as ESD or power transients, due to the low frequency response. Damage is possible from large transients, so the normal ESD precautions are still necessary on analog I/O circuits.

Let's look at how to prevent or solve some of the more common analog EMI problems.

Grounding. . . This is the first place we look when dealing with analog EMI problems. Because the signal levels are so small, even a few millivolts of "ground noise" may be enough to cause an EMI problem.

For frequencies below 10 kHz, single point grounds (SPG) are very effective. As long as there are no common ground paths (ground loops) no noise voltages can sneak into the system. Above 10 kHz, parasitic capacitance can form high frequency loops anyway. That's why SPGs work so well against 50/60 Hz hum, but may be completely ineffective against "digital noise" or RF interference.

As we mentioned in the last KGB, we often draw a "ground map" when attacking a possible ground problem. We try to assess both low frequency and high frequency ground performance.

Circuit Balancing. . . This technique is also most effective at frequencies below 10 kHz. Since many EMI problems are common mode, using a balanced circuit (with a high CMMR, or common mode rejection ratio) cancels the EMI voltages. This can be very effective against both conducted and radiated 50/60 Hz interference.

As frequencies increase, however, parasitic capacitance and inductance can "unbalance" even the best circuit.

Power Regulation. . . Noise coupling through the power system is similar to sneak coupling through the ground. A few millivolts of ripple or hash can easily modulate a sensitive analog circuit. That's why separate analog power supplies, good regulation, and power bypassing are so important.

Watch out for slow sags and surges coming through the power supply from the AC mains. This can also cause a slow modulation of the analog circuitry. Even in simple analog circuits, it pays to include local voltage regulation.

A KGB BULLET. . .

While we in the EMI community use ***electric field intensity,*** our engineering colleagues in the communications world use ***power density.*** Here are some handy conversions to help you:

$E\ (V/M) = 61.4\sqrt{P\ (mw/cm^2)}$
(FAR FIELD — 377 OHMS)

100 V/M = 2.65 mw/cm²	10 mw/cm² = 194 V/M
10 V/M = 26 uw/cm²	1 mw/cm² = 61 V/M
1 V/M = 0.26 uw/cm²	0.1 mw/cm² = 19 V/M

dbuV = dBm + 107 (50 OHM SYSTEM)

Focus on Analog Circuits. . . *continued*

Cables. . .This area is crucial in dealing with analog EMI problems, since the cables and their shields can provide both *sneak ground loops* and also *sneak antenna* for unwanted noise.

Questions arise regarding shielded cable versus twisted pair. Here are some guidelines. For *high impedance circuits,* electric field coupling is likely, so a shielded cable will help. For *low impedance circuits,* magnetic field coupling is likely, so twisted pair wiring will help, and the more twists, the better. If you don't know ahead of time, shielded twisted pair is a safe bet.

Questions also arise regarding the cable shield grounds. Here are some more guidelines. For *low frequency threats* (50/60 Hz), ground at one end to maintain the single point ground. For *high frequency threats* (10 kHz and up) ground at both ends to stop high frequency leakage. (You may also need high frequency filters.) If you need both, consider a *hybrid ground*. . .connect one end of the shield to chassis through a 0.01-0.001 uf capacitor. Be sure to keep the leads short.

Cabinets and enclosures. . .If you are facing high frequency threats, you need to include high frequency shielding. For low frequencies, paying attention to power, grounds, cables, and circuit balancing is often adequate.

Book Reviews. . .

Here are some books that may be of interest to analog and power supply designers.

Noise and Other Interfering Signals by Ralph Morrison, John Wiley & Sons, 1992. This book covers interference and noise sources, and emphasizes coupling mechanisms. Written at a basic level, it's a good addition to Ralph's other books on EMI and instrumentation.

Power Line Filter Design for Switched Mode Power Supplies, Mark Nave, Van Norstrand Reinhold, 1991. Mark is a power supply design specialist, and has published numerous articles on the subject. Now all that knowledge is available in one place. If you design power supplies, this book should be in your library. (You will also want MIL-HDBK-214B, *Design Guide For Electromagnetic Reduction In Power Supplies* in your library, too.)

EC 1996 Now Official. . .

As expected, the European Community officially extended the deadline for meeting the EMC Directives until December 31, 1995. The announcement was recently published in the Official Journal of the European Communities.

Until 1996, manufacturers may use either the EC directives, or may use the appropriate national EMC regulations of the importing country. (Our thanks to Dan Hoolihan of AMADOR for this information.)

New Light Bulbs an RFI Source?

Concerns have already been raised about possible RFI from a new RF powered light bulb design. We understand the National Association of Broadcasters is considering legal action.

The manufacturer, Intersource Technologies Inc. of Sunnyvale, California, says the light bulbs will meet Part 15 rules, and that the bulbs will operate at 13.56 MHz, in the ISM (Industry Scientific and Medical) band. The thought of *billions and billions* of RF sources is an interesting one to contemplate. We'll keep you posted.

> Good technology is like pornography. . . you know it when you see it.
>
> *— EE Times, May, 1992*

Article on Grounding. . .

If you're interested in grounding, as we are, be sure to read *Grounds for Signal Referencing* by Anthony N. St. John in the June 1992 IEEE Spectrum. A very practical and easy to read article on ground noise written by a hands on practitioner from San Diego Gas and Electric.

A KGB BULLET. . .

When dealing with transients such as ESD, it can be helpful to compute wire lengths in terms of *volts per inch.* Here's how to do it . . .

$V = L\ di/dt$, which becomes $V = Li/tr$

For L = 20 nh/inch (typical wire inductance)
i = 10 amps (typical peak ESD current)
tr = 1 nsec (typical ESD rise time)
V = 10 volts per inch of wire.

Thus, if you have a ½ inch lead to ground, ESD will generate a peak voltage of 5 volts across that ground. A good reason to keep your leads short!

(Thanks to Doug Smith, DC Smith Consultants)

EMI Design Seminars. . .

If you'd like instruction on how to design or install equipment to minimize EMI problems, we can help. We cover common problems and solutions, including FCC/VDE/EC compliance, ESD, RFI, power, and self compatibility.

Our focus is on design and troubleshooting, not testing and regulations. **Our courses are aimed at the design and systems engineer who needs to know how to identify, prevent, and fix EMI problems.** You get the benefit of our years of EMI design/trouble-shooting experience.

Courses vary from one to four days, with two or three days the most common. **We have several successful and proven formats,** or we can tailor classes to your needs.

In addition to our EMI experience, we are also very experienced as technical instructors. In fact, we've been teaching high-technology almost as long as we've been solving EMI problems. At Kimmel Gerke Associates, you get more than just our years of EMI experience. . . you also get our years of technical training experience.

Expert Witness Help Available. . .

Another service we offer our clients is technical support with legal issues. Although we hope that you and your products don't end up in court, we might be able to help if you do.

We've both had experience as expert witnesses so we understand the special problems that occur during litigation. We also understand how to work with your attorneys on technical issues. We're both Registered Professional Engineers, which is almost mandatory in this area.

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