KIMMEL GERKE Bullets

MEMBER AMERICAN CONSULTING ENGINEERS COUNCIL

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Welcome to KGB. . .

And to this issue of our issue of our "personal communications" to our friends, clients, and colleagues. We hope we're able to help you better understand how to *identify, prevent, and fix EMI/EMC problems*.

This issue focuses on components, the most basic of electronic building blocks, and how they affect (and are affected by) EMI problems. Since all EMI problems begin or end at the individual circuit level, understanding component effects is crucial to understanding all EMI problems and solutions.

If you like the KGB and want to receive future issues, be sure to *please return the enclosed post card*. And add any comments you wish . . .we always enjoy those. Thanks again, and please call if we can help you.

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

EMI-Toolkit™ Software. . .

We've delivered quite a few copies of our new software package, and we've had good feedback from many users. Thanks to all of you who ordered it, and were patient as we finished up the "odds and ends". If you haven't ordered your copy, take a look at the ad on the back of the KGB, or just give us a call for more details.

PLEASE REQUALIFY. . .

Please return the enclosed post card if you wish to continue to receive *Kimmel Gerke Bullets*. If you joined us or updated your address since January 1993, you can disregard this. *If in doubt, send in the card, and we'll keep you on our list.*

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

Shows and Conferences. . .

Here are some shows and conferences in which we'll participate, and that may be of interest to you. Call if you'd like more details on any of these events:

IEEE 1993 Symposium. . .August 9-13, 1993, in Dallas Texas. Sponsored by the IEEE EMC Society. Technical sessions, plus three days of exhibits. We'll be there all five days. . .hope to see you there, too.

Eighth Annual Minnesota EMC Event. . . Wednesday, October 20, 1993, at the Thunderbird Hotel in Bloomington, MN. Cosponsored by AMADOR Product Services and Kimmel Gerke Associates. *Please note the date change. . .this year, the show is on Wednesday, not Thursday as in the past.* Full day seminars will also be offered before and after the show (Tuesday and Thursday). We've got some new plans, so be sure to join us.

Medical Design & Manufacturing West 94 Conference. . .February 1-3, 1994, at the Anaheim Convention Center next to Disneyland. Sponsored by *Medical Devices & Diagnostics Industry* magazine. We'll be presenting a paper on EMI and Medical Devices. We recently concluded a six-part series of articles on EMI for *MDDI* magazine, and are pleased to be part of their conference.

Winter Getaways. . .

Need a winter break? Want to learn more about EMI troubleshooting? Then join us in Orlando or San Diego this winter for one of our expanded three day seminars with Tektronix. In addition to two days on EMI design, we'll host an optional third day workshop on EMI troubleshooting. Held in a roundtable 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 seminar to attend the workshop. If you've 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.

Kimmel Gerke Bullets is a newsletter on electromagnetic interference/compatibility (EMI/EMC). Published by Kimmel Gerke Associates, Ltd., 1544 North Pascal, St. Paul, Minnesota 55108 (612) 330-3728.

Focus on Passive Components. . .

Many designers assume (mistakenly) that the simple passive components they use can not cause EMI problems. After all, passive components are almost ideal, aren't they? Unfortunately, this is not true in the real world of EMI, and many EMI problems are due to unexpected passive component behavior.

In this issue of the KGB, we'll look at the subtle ways EMI can affect passive components, and we'll share some of our thoughts in selecting components with EMI in mind.

Most passive component EMI problems are due to exceptions to the rules. For example, when is a capacitor not a capacitor? When it's an inductor (often due to lead length) at high frequencies. When is an inductor not an inductor? When it's a capacitor (due to wire spacing) at high frequencies.

We often refer to these exceptions as the *hidden schematic*. Most of the time these hidden components set an upper limit on frequency. Here are some of our recommendations on selecting passive components to solve EMI problems.

Capacitors. . . As frequency increases, the impedance of a capacitor decreases, right? In theory, yes, but in reality, the upper frequency response is limited by internal inductance and resistance, and by external inductance due to lead length. Here are some guidelines we use for capacitors:

• Aluminum Electrolytic	100 kHz
• Tantalum Electrolytic	1 MHz
• Hi K Ceramics	5 MHz
• Paper	5 MHz
• Mylar	10 MHz
• Polystryene	500 MHz
• Mica	500 MHz
• Ceramic	1000 MHz

At high frequencies, the external inductance due to lead length becomes a significant factor. As a rule of thumb, this inductance is about 20 nanohenries per inch of lead length. Since this is in series with the capacitor, this lead inductance forms a series resonant circuit. At frequencies higher than the resonance, the capacitor becomes an inductor, making it ineffective for decoupling.

For example, one inch of lead length on a 0.01 uf capacitor resonates at 11 MHz; at ¼ inch, the frequency is still only 23 MHz. The key message is to keep the leads short for high frequency applications! Other techniques, such as straps and ground planes may also be needed to further lower the lead inductance, so the capacitor can "capacitate" as we intended.

Inductors. . . As frequency increases, the impedance of an inductor always increases, right? Once again, theory is nice, but in this case, the upper frequency response is limited by capacitance between the windings.

We use a simple rule of thumb for small wire wound inductors. We just assume they don't work very well above about 50 MHz. That's not such a serious drawback, since 50 MHz is where most EMI ferrites start to become effective, and they are usually good to at least 500 MHz.

Above 500 MHz, the end-to-end capacitance can limit the ferrite effectiveness. (Above 500 MHz, baffles or shields are often needed to limit this end-to-end effect.)

We really like EMI ferrites for ESD and RFI use. Not only do they minimize the capacitive problems, they are also resistive above 50 MHz. (Even small ferrite beads look like 50-100 ohms at 100 MHz). Unwanted EMI energy is dissipated as heat, rather than just shoved around to cause problems in another part of our equipment.

Watch out for inductor saturation. We've seen cases where filters wouldn't filter (and ferrites wouldn't ferrite) because the current was too high. For EMI ferrites (Type 43 or 28), we use the formula $I = 10 R$, where R is the radius in cm, and I is the current in amps where saturation commences for one turn. Thus, a small single turn bead is good for about 100 ma, and a ferrite the size of a 2 watt resistor is good to about 5 amps before it saturates.

Resistors. . . What can go wrong with something as simple as a resistor? Several EMI problems can occur with this humble component. First, wire wound resistors exhibit inductance, so they should be avoided where high frequencies are a concern. (Film resistors under 2K are OK since they have less inductance than a wire-wound.)

Second, thin film resistors don't handle overstress very well, so they should be not be used in ESD situations. We like plain old carbon composition resistors here, or our friends the ferrites which look a lot like carbon resistors at ESD frequencies.

continued on the next page

A KGB Bullet. . .

Bill found a good source for military standards, which may be ordered from the following:

Naval Publications and Form Center
Standardization Document Order Desk
700 Robins Avenue, Bldg. 4, Section D
Philadelphia, PA 19111-5094
215-697-2667 or -2179

They don't accept phone orders, but will accept fax orders (215-697-2978). One copy will be sent, free of charge. (Check your university document center, too.)

Focus on Passive Components. . .
continued

Third, resistors can have end-to-end capacitance like inductors or ferrites. Above 500 MHz, special baffles or shields may be needed to prevent high frequency current from going around the resistor.

Transformers. . .The last "suspect" we'll look at today is the transformer. Although a theoretical transformer offers infinite "common mode" isolation from primary to secondary, real world transformers lose this isolation due to interwinding capacitance. Unfortunately, this allows a lot of spikes (power transients, lightning transients, EFT) right into the power supply.

For this reason, Faraday shields are common and quite popular for "noise sensitive" transformer applications. We've even solved vexing power disturbance problems with simple shielded transformers. Fancy UPS systems and regulators are not always necessary.

Like all other components, shielded transformers must be installed properly. Keep the shield ground leads short, and separate the input and output wiring to prevent high frequency coupling.

Summary. . .We hope we've helped provide some insights into the EMI issues and passive components. Often, it's the little details that make big EMI successes.

By the way, the capacitor values were from a table on "Capacitor Selection" in our *EMI-Toolkit*™ software package, which also has a "Capacitance Resonance" calculator. The *EMI-Toolkit*™ also has a "Ferrite Selector". We often use these ourselves when selecting components for EMI use.

> While nothing is certain but death and taxes, at least the death rate remains constant — at one per person.
> — *The Lion*, May 1993

Where's the KGB been???

Some of you have inquired about the *KGB*, wondering if you missed a copy. Probably not — we just got behind and slipped our schedule a bit due to a rather heavy "literary" load in other areas. We just completed a six article series for *Medical Devices & Diagnostic Industry* magazine, and we recently submitted another series to a leading electronics magazine. We also presented some detailed papers on "ESD" and "Uncommon EMI Problems" at the *EMC/ESD International* conference this spring.

Sometimes we have to remind ourselves that our main business is helping our clients *solve* their EMI problems, not just writing about them. Anyway, thanks to those of you who were concerned, and who enjoy our efforts.

Tektronix EMI Design Seminars. . .

Once again, we'll be working with Tektronix to bring you our popular *Design for EMC* seminars. No, this is not just another course on grounding and shielding, nor about test and regulations. Rather, it's two days that focus on key EMC issues faced by designers, with an emphasis on practical information, not theories and formulas.

We've had good reviews on these seminars. Designers tell us they like the focus on EMC design, and that they really appreciate the fact that we' don't just simply teach about EMC, but that we make our living solving real EMC problems "in the trenches".

These seminars will be held throughout the United States, so one will likely be coming your way. As a KGB reader, you'll receive a special announcement about 4-6 weeks in advance of a seminar in your area. *The next seminars are scheduled in September for Dallas, Santa Clara, and Rochester, New York.*

KGB = CIA. . .

At the EMC/ESD International conference, Ron Hudson of Harris Corporation offered this: *Kimmel Gerke Bullets equals Compatibility In Action.* (Groan. . .)

Book Reviews. . .

Transmission Line Design Handbook, by Brian C. Wadell, 1991, Artech House, Norwood, MA. This book is a cookbook on calculating transmission line parameters of about any transmission line you can think of (and some you never even thought of.) Good reference on materials used in transmission lines, too. The equations are not simple, but are usable for computer calculations.

IEEE Standards Collection: Electromagnetic Compatibility, 1992, IEEE, New York, NY. This is a collection of 27 common and not-so-common IEEE standards on EMC. Several are sponsored by IEEE societies other than the EMC society. A useful addition to any EMC technical library.

A KGB Bullet. . .

As a rule of thumb, we assume that a filter starts to lose effectiveness at two to three decades above the cutoff frequency, due to parasitic capacitance and inductance creating unwanted resonances.

As a result, we often cascade small (high frequency) filters in series with large (low frequency) filters. We call this the "woofer-tweeter" approach. Like audio speakers, more than one filter (speaker) is often needed to cover the entire frequency range of concern.

EMI-Toolkit™

A New and Unique Concept in EMI Software

EMI-Toolkit™ is a collection of over thirty of our favorite EMI formulas, graphs, and tables that we use on a regular basis as EMI consulting engineers. They help us assess and evaluate problems, and provide quick approximations to common EMI problems. These proven tools are now available to you as an easy to use Windows (3.1) program.

- ***Estimators — Used to Calculate & Predict Levels***
- ***Selectors — Used to help choose components***
- ***Tables — Containing Common Values***
- ***Conversions — Used to convert units and values***
- ***Limits & Regulations — FCC, VDE, CISPR***
- ***Reference Data — Useful Facts & Figures***

EMI-Toolkit™ is like having an EMI reference handbook (or perhaps even an EMI consultant) right at your fingertips. Only $100 for single user copy or $500 for a single-site/single-network copy. A corporate license is also available.

For more details, or to place an order, call 612/330-3728. We accept Master Card, VISA, purchase orders, or checks. Minnesota residents, please add 6.5% sales tax.

RFI Articles. . .

We've published several articles and papers on RFI (radio frequency interference) as an EMI problem. Give us a call at 612-330-3728 if you'd like any of these articles:

- *Electric Field Levels Around a Typical Amateur Radio Station,* IEEE EMC Symposium, 1992
- *Microprocessors and VHF Radios — Mutual Antagonists,* EMC EXPO 1989
- *Computers as Victims of RF Interference,* RF Design Magazine, November 1989
- *Microprocessor Interference to VHF Radios,* RF EXPO, February 1988

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