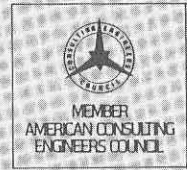


KIMMEL GERKE *Bullets*



Spring, 1992
Vol. 3, No. 3

Welcome to KGB. . .

And to our "personal communications" on electromagnetic compatibility issues for our friends, clients, and colleagues. By the way, we've really enjoyed meeting and hearing from so many of you in recent times.

This issue focuses on grounding. . .probably one of the most controversial and least understood areas of EMC. Ask a dozen engineers how to ground something, and you'll likely get a dozen (or more) answers. Nevertheless, grounding is one of the primary tools of the EMC trade.

We'll discuss different functions of grounds, and we'll pass along some helpful hints. We can't cover everything in this article, but perhaps we can shed some light on the issues.

If you like the KGB and want to receive future issues, **please return the enclosed post card.** And add any comments you wish. . .we always enjoy those. Finally, **give us a call if you need any help to identify, prevent, or fix your EMC problems.**

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

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 1992, you can disregard this. . .*unless you changed your address.*

Since many businesses no longer deliver bulk mail, feel free to use your home address. Besides, if you change companies, you'll continue to receive the KGB. By the way. . .*our list is very private, and 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 on any of these events.

MIDWEST EXPO 1992. . .The largest electronics show in Minnesota, aimed at the general technical community. Held May 19-21 at the Minneapolis Convention Center. We'll be presenting our popular three hour session on *"20 Common EMI Mistakes. . .and How to Avoid Them."* This talk has been well-received at other shows, and this is the first time in the Twin Cities.

EMC EXPO 1992. . .This show has been **CANCELED.** Originally to be held in Washington DC in late May 1992. We were scheduled to attend and present a session. See article inside for more details.

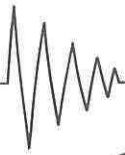
IEEE 1992 EMC Symposium. . .August 17-21 in Anaheim, California. Technical sessions, plus three days of exhibits. Daryl will present a paper titled *"Electric Field Levels Around a Typical Amateur Radio Station."* Hope to see you there.

Seventh Annual Minnesota EMC Event. . .October 22 at the Thunderbird Hotel in Bloomington, MN. Co-sponsored with Amador and Kimmel Gerke Associates, and part of EMC-WEEK-92. We've got some new plans brewing, so mark your calendars to attend.

Denver EMC Show a Winner. . .

The EMC/ESD International show, held in Denver in April, was a big success. . .very well attended and very well managed. This was the first year for this show, sponsored by *EMC Test and Design Magazine.* We saw many friends and clients at the show, and everyone was quite happy. Many outstanding technical papers were presented. . .a very strong technical program. (We gave two papers ourselves, both well received.)

The 1993 show will be held next April in Denver. We'll be there, and we hope to see you there too.



Focus on Grounding . . .

According to the Electric Power Research Institute (EPRI), up to 80% of the "power quality" problems with electronic equipment may be due to poor wiring and grounding practices at the customer facilities. As EMC engineers, we see grounding as a major contributor to noise problems, at both the systems and equipment levels.

In this issue of the KGB, we'll look at grounds from a systems point of view. We'll look at equipment grounding issues in a future issue.

Many ground problems are due to misunderstandings about what a particular ground is supposed to do. This is compounded by contradictory guidelines, such as "single-point" versus "multi-point" grounds. And there is always the temptation to "improve" the grounding by driving more ground rods into the earth. Hopefully, this article can help clear up some of the confusion about grounds.

What is a ground, anyway? . . . In the simplest terms, a "ground" is a "return path for current flow." Sometimes we forget that current always "returns to its source." For convenience, we often use a ground path (rather than a dedicated conductor) back to the source of current. At KGA, we like the "sewer analogy" . . . consider a ground a path for "used electrons" if you'd like . . . and remember it's a path, not a "cesspool."

Why use a ground? . . . Grounds are used for many reasons, including power, safety, lightning, EMI, ESD, and RF. Sometimes, one ground may perform several functions . . . intended or unintended. This is why grounding can be such a sticky EMI issue.

Grounding requirements may vary widely due to vastly different current and frequency requirements. As a result, the specific grounding techniques may vary widely as well . . . a general purpose ground may not solve a specific problem at all. Let's look at several of these areas.

Power ground . . . In power systems, this is often referred to as a "neutral." This conductor carries current back to the source, such as a transformer, service panel, or battery. This type of ground may carry large currents (many amps), but needs to only work at relatively low frequencies (DC or 60 Hz). As a result, the limitations are usually due to resistance and current carrying capability.

Safety ground . . . In power systems, this is the conduit or the "green wire." Unlike the neutral, this conductor is only supposed to carry current in a fault condition, such as a short circuit to a cabinet. Like the neutral, it must carry large currents at low frequencies, but only for a brief time. The limitations are also due to resistance and current carrying capability.

Lightning ground . . . This type of ground provides a controlled connection to the earth for lightning currents to follow. A lightning ground must carry huge currents

(sometime over 100,000 amps), but only for tens of microseconds. Due to the transient nature of lightning, the frequency content is in the 300 kHz to 1 MHz range. The limitations for lightning grounds are due to inductance and to peak energy requirements. Thus, solid connections with a minimum of bends (inductance) are needed.

EMI Ground . . . For "noise" control, the EMI ground often must function over a very wide frequency range, from DC to many GHz. At the same time, the currents may be small, often in the microamp or milliamp range. Thus, low inductance paths with very solid low resistance/low inductance connections are often needed. Good examples of EMI grounds are ground planes or ground grids.

ESD Ground . . . A special case of an EMI ground is for electrostatic discharge. A human body discharge can result in tens of amps, but only for nanoseconds. Due to the fast risetimes, the frequency requirements are in the 300 MHz range. Thus, low inductance grounds are mandatory for ESD. Sometimes we use "resistive" or "soft grounds" for ESD to limit the peak transient current as well.

RF Ground . . . Communications antennas often depend on a nearby "ground" or "image plane" to return currents to the antenna. The importance of this type of ground decreases with the distance from the antenna, but close to the antenna, significant "RF ground" currents can be flowing. This includes both intended and unintended conductors that are near the antenna.

It should be clear by now that there are many types of grounds, with many different functions. Often, a ground system may be serving several needs (safety, lightning, EMI), while at other times it serves only one need. Different rules apply for different grounds, so using one type of ground for another application may cause unwanted problems. Finally, grounds can provide "sneak paths" . . . the current doesn't care which path it takes, as long as it goes back to the source.

Ground system analysis . . . When faced with a possible system grounding problem, we find it useful to make a "ground map." The objective is to identify both the grounding needs, and all the various types of grounding paths.

A KGB BULLET . . .

A quick and dirty estimate for the "upper frequency" of concern for FCC/VDE emissions is to multiply the highest clock frequency in the system by 20. This becomes a useful design frequency for shielding, crosstalk, etc.

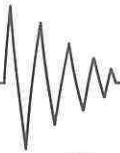
For example:

10 MHz Clock = 200 MHz

33 MHz Clock = 660 MHz

50 MHz Clock = 1000 MHz

Keep in mind if your clock is over 108 MHz, the FCC now requires you to test to beyond 1 GHz.



Focus on Grounding . . . continued

Then we start asking questions. What is the safety ground path? The neutral path? (Are they crossed? Shouldn't be, but it happens.) How are the filters connected to the EMI ground? Do we have special analog and digital ground requirements? (Are they properly isolated?) Do we have any "sneak paths" through the grounds? Do we have unwanted mixing of signals in the ground (60 Hz hum into an analog system, or spikes into a digital system?) Are the ground connections adequate for both the current and frequency needs?

Between the "ground map" and the questions they raise, the problems (and their solutions) often become clear.

What about earth ground? . . . In the US, power systems are typically connected to an "earth ground" at the service entrance and at the power poles. This is primarily to protect against lightning or faults on high voltage transformers. In many other parts of the world, the power systems are not "earthed," except at the power station.

A common misunderstanding we often see is the urge to "drive more ground stakes" to lower the ground impedance. This may help if your primary concern is lightning. . . otherwise, it usually indicates a desperate "shotgun" approach that doesn't address the real problem.

First, the earth is not a "sink" for EMI noise current (remember our sewer analogy), and second, it's difficult to obtain a low impedance, high frequency connection to the earth anyway. You are much better off if you analyze the problem, determine the real needs, and then design an appropriate solution.

A final comment on safety grounds. . . These ALWAYS take precedence over any other grounding need. **Before making any grounding change or modification, be sure the system is safe!**

Magnetic Fields Conference . . .

Daryl attended the EPRI sponsored "End Use Magnetic Fields Conference" in Raleigh, North Carolina in early April. Two days of talks and meetings on magnetic field biological research . . . and a good cross section of attendees from industry, power utilities, and universities. It was very interesting to hear from several of the research leaders in the EMF arena.

EMC Expo Cancelled . . .

We are sorry to report that EMC EXPO, scheduled for late May in Washington DC, has been cancelled. We supported this show since its inception in 1986, and found it particularly useful for the newcomer to EMC.

No word at this time on future plans, but due to decreasing attendance over the years, it seems unlikely that the show will return. We're told that the proceedings are available for purchase, and that selected articles will appear in future issues of *EMC Technology Magazine*.

Our Phone Call Policy . . .

Our policy on telephone questions is simple. **If we can answer it right away, it's FREE.** If you need detailed information, and it will take some time, we'll give you an estimate. So if you have a quick EMI question, need vendor information, or ??? — just give us a call.

No catches or hassles with us. If you are reading the KGB, it's because you are a client, colleague, or friend that has an interest or concern in EMC. Frankly, we enjoy hearing from you . . . and **it's our way of saying THANKS for your business and referrals.**

Amador Joins TÜV . . .

We just learned that Amador, a Minnesota based EMC and Product Safety laboratory, has been acquired by TÜV Product Service. Most of our Twin Cities readers know Amador as an excellent test lab, as well as the co-sponsor with Kimmel Gerke Associates for the annual MINNESOTA EMC EVENT.

According to Dan Hoolihan, Chief Operating Officer at Amador, it will be business as usual with an increased emphasis on product safety. This move will also give Amador ready access to the critical European Community marketplace. Our best wishes to our friends at Amador.

Book Reviews . . .

Here are two books that may be of interest to designers of high performance digital systems.

"*High Speed Digital IC Technologies*" by Marc Rocchi, Artech House, 1990. This book is a collection of articles that focus on current and emerging IC technologies. Topics include structures, processes, design, performance, and speculation on future technologies. This book should be in the high performance designer's library.

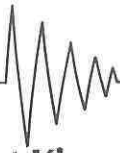
"*GaAs FET Principles and Technology*" by James DiLorenzo and Dean Kanadelwal, Artech House, 1982. This is also a collection of articles that are heavily slanted at GaAs design, with interesting articles on digital, power, and small signal applications. A bit dated, but of interest to anyone starting to design with GaAs technology.

A KGB BULLET . . .

Here are some guidelines for "signal-to-reference" lines in connectors and cables, from a recent article by Matt Sucheski of AMP:

- Risetime > 3 nsec = 8:1
- Risetime 3-1 nsec = 4:1
- Risetime < 1 nsec = 1:1

Our advice . . . be sure to spread the returns throughout the cable. . . don't bunch them together at one end. (REF: "*Level-3 PC-Board Connectors Edge Toward High Speed Applications*," Matt Sucheski, *Electronic Design*, March 19, 1992)



About Kimmel Gerke Associates. . .

Often we are asked to give a quick description of what we do. If you are asked by someone needing EMC help, here are six key points about KGA. . .

Key Point I. . . We are a two-man electrical engineering firm that specializes in electromagnetic interference and compatibility (EMI/EMC) issues. These include five areas:

- **Regulatory Compliance** (FCC, VDE, IEC, MIL-STD-461, etc.)
- **Radio Frequency Interference** (Communications systems)
- **Electrostatic Discharge (ESD)**
- **Power Disturbances** (Transients, magnetic fields, etc.)
- **Self-compatibility** (High speed digital, analog, etc.)

Key Point II. . . We are Registered Professional Engineers (PE), and between us, we have **over 50 years of industry experience.**

Key Point III. . . We are not a test lab — **our emphasis is on EMC design and troubleshooting.** While we are knowledgeable about key EMC tests and regulations, our focus is on design issues, and how to identify, prevent, and fix EMC problems. **This includes training as well as engineering help.**

Key Point IV. . . We serve many industries, and our support ranges from individual equipment to large systems. We've helped clients in the following areas:

- **Computers** (PCs to supercomputers)
- **Industrial Controls** (Individual controls to full systems)
- **Vehicular** (Automotive, railroad, heavy machinery)
- **Medical** (Diagnostic, clinical, patient connected)

- **Military** (MIL-STD-461, EMP, TEMPEST, HERO)
- **Architecture** (Shielded rooms, lightning, power)

Key Point V. . . We are an independent firm with no outside affiliations. **Our advice and recommendations are free from any bias or other business concerns.**

Key Point VI. . . All client projects are treated in complete confidence. Unlike many other consulting firms, you won't even see our clients named in our brochure.

Please give us a call if we can help you with your EMI/EMC problems or training needs. **And please pass our name along to your colleagues. . .your referrals are always sincerely appreciated.**

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