KIMMEL GERKE Bullets

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Welcome to KGB

And to the fifth issue of our "personal communications" to our friends and clients, complete with **information to help you identify, prevent, and fix EMI/EMC problems.**

This issue focuses on design reviews, a service that we've been providing for an increasing number of our clients. Many of these clients have paid a painful price for neglecting EMI/EMC in earlier projects, so they are reluctant to go through another disaster. Other clients have found that an "EMC review" can help prevent other surprises as well. The bottom line. . . better designs.

We'd like to help you prevent EMI/EMC problems in your designs. The best time for a design review is right at the start — that's when you have the most options at the least cost. Remember, $5K at design time can often save $50K in retest and rework at the end of a project. Give us a call for more details.

Best regards,

Daryl Gerke, PE, and Bill Kimmel, PE

A KGB Bullet. . .

dB Conversions (50 OHM Impedance)

From \ To	dBm	dBv	dBmV	dBuV
dBm	0	−13	+47	+107
dBV	+13	0	+60	+120
dBmV	−47	−60	0	+60
dBµV	−107	−120	−60	0

Shows and Conferences

Here are some shows in which we will be participating. Give us a call if you'd like more information on any of these events.

Midwest Electronics Expo. . . May 21-23 at the Minneapolis Convention Center (note new location). This is the largest electronics show in Minnesota, and is aimed at the general electronics community. We are exhibiting (Booth 1707), and chairing two EMC related sessions. (Dan Hoolihan of Amador will be chairing a third EMC session.) Don't miss these EMC technical sessions:

—*High Performance Design*, Bill Kimmel, chairman
—*Power Disturbances*, Daryl Gerke, chairman
—*European EMC Requirements*, Dan Hoolihan, chairman

Santa Clara Valley EMC 91. . . June 12-13, Santa Clara Convention Center, Santa Clara, California. We plan to exhibit at this EMC colloquium and product exhibition, which is sponsored by the Santa Clara Valley IEEE EMC Society.

EMC-EXPO-91. . . June 25-27, at Walt Disney World Village, Buena Vista Palace Hotel, Orlando, Florida. Come down to Florida, and bring your family to Disney World! We'll be chairing the following sessions:

—*20 Common EMI Design Mistakes*, Bill Kimmel, chairman
—*Power Disturbances*, Daryl Gerke, chairman

IEEE 1991 International Symposium on Electromagnetic Compatibility. . . August 13-15, at the Hyatt Cherry Hill, Cherry Hill, NJ. As usual, we'll be there. . . hope to see some of you there, too.

Power Quality Seminar. . .

Here is a seminar you may find of interest, that concentrates on measuring and solving electrical power quality problems. **March 11-13, at the Northland Inn and Conference Center, Brooklyn Park, MN.** Presented by BMI, and hosted by Measurement Engineering. Cost $950, group discounts available. Call Roger Montague at 612-546-2021 for more details.

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Focus on Design Reviews

Many of our clients now include an **EMC Design Review** as part of the design process. They have discovered (some painfully) that the earlier you address EMC issues, the more options you have, and the lower the costs.

For example, careful circuit board design minimizes the demand for shielding, and may even eliminate it. If you've been even moderately careful with the circuit design, you may get by with an inexpensive enclosure. If you have ignored EMC concerns, however, you may need an extraordinary (and expensive) enclosure to cover your sins.

Here are some thoughts, comments, and philosophies on EMC design reviews, as seen and practiced by Bill and Daryl.

What's in an EMC design review. . . First, an EMC design review is *not* a full-blown review; rather, it focuses on specific EMC issues. ***It addresses EMC threats*** (regulations, ESD, RFI. . .), ***design constraints*** (cost, volume. . .), ***and design strategies*** (boards, cables/connectors, shielding, filters. . .)

Second, the EMC design approach is *not* cast in concrete (at least not with Kimmel-Gerke Associates); rather, the design team is actively involved. Together, we identify and assess the risks, and discuss the design approaches and options. Recommendations are then documented in a summary report.

Finally, the EMC support is not finished; rather, ongoing support is provided through the design process. This can range from phone call support to follow up meetings, and often some interim engineering tests.

When to hold an EMC design review. . . As soon as possible, but certainly before committing the design to hardware. If possible, start before the circuit and bus philosophy is settled, since these have a major impact on EMC. If you make unwise choices here, you will need to work hard to overcome them.

But often many of the decisions have already been made, and you have to live with them. Given that, a good time to begin looking at EMC issues is during the initial circuit and mechanical design phase, before the circuit boards and mechanical packaging are completed.

EMC Threats. . . The first threat is **emissions**, which is quite often a regulatory issue. Your requirements may be nominal, as in the commercial FCC Class A limits, or quite severe, as in military or automotive limits.

The second threat is **susceptibility** (also known as immunity). This includes electrostatic discharge (ESD), high level radio frequency fields, and power disturbances. All three of these areas will soon have mandatory requirements in Europe.

The third threat is **self-compatibility**. This includes internal jamming, crosstalk, and analog/digital isolation. Even without mandatory limits, your design can still fail EMC.

Design constraints. . . These must be considered in any EMC review. What are the environmental requirements? If avionics, weight is a major factor. If commercial or automotive, cost will often be a driving factor. Unit volume is also a factor - on a high volume, a few cents may be important; on a low volume, you may never recover additional engineering costs by trying to shave that last dollar or two.

Design strategies. . . The design approach for EMC boils down to two strategies — **containment** and **suppression**. Containment involves building a shielded enclosure (this may also include filters and cables) which blocks the passage of electromagnetic energy into or out of the system. Suppression involves designing the electronic circuits to minimize emissions and susceptibility.

While it is possible to design an enclosure that negates internal design efforts, they are usually very expensive. As a practical matter, complete shielding is usually not feasible, except in military or other high cost designs.

Suppression techniques, on the other hand, can significantly reduce the shielding needs. In benign environments, it is often possible to eliminate the need for shielding. This is true even in some extreme environments, but is not as common.

The key point is that reasonable steps in the electronics design can spell the difference between an expensive shielded enclosure and a more casual, inexpensive package. This is where a design review can really help. A review of the **circuit board layout** can identify potential EMI "hot spots." A review of the **mechanical packaging** can uncover potential weak spots. A review of the **cables and connectors** can identify potential "EMI antennas". All three areas — circuit boards, cables/connectors, and enclosure must be addressed. The **power system, grounding strategy, and I/O** must also be addressed as well.

Tradeoffs and risks. . . An interactive review between the designers and the EMC specialist is essential. The EMC engineer can identify problem areas and recommend solutions, but the designers must translate that into a workable solution. And that can best be done by negotiating with the EMC engineer's recommendations. Between the EMC engineer and the design team, a workable approach can evolve.

It is important to understand that EMC is far from an exact science. Thus, it is not always possible to be as precise as other design areas. One can overdesign, or one can take steps to minimize the risks.

This is where interim **engineering tests** can help. Cables, connectors, and enclosures can be tested for shielding effectiveness. Even partially populated circuit boards can be tested for emissions or susceptibility. Expensive compliance testing is not needed at this phase — even simple, "quick and dirty" tests can provide "real time" feedback.

(continued on pages 3)

Focus on Design Reviews *(continued)*

The key point here is that while risks can not be eliminated, they can be identified, assessed, and controlled. Design tradeoffs can be made, and fall-back positions identified.

Costs. . .The cost varies with the complexity of the system, but the cost for a typical design review range from $3000 to $6000. The cost savings can easily reach ten times that amount — at the end of a project, retesting and redesigning becomes very expensive.

Remember our advice. . . *an ounce of prevention can save a pound of shielding*. . . give us a call if you'd like more information on design reviews.

Book Review

Capacitance, Inductance, and Crosstalk Analysis, by Charles S. Walker, Artech House, 1990. This book does a thorough job of developing equations for calculating the most common cable and circuit board crosstalk configurations. The calculations assume lumped circuit representations, which can become inaccurate with higher frequencies. The good news is tht lumped circuit calculations will predict greater than actual crosstalk, so the calculations give a safe worst case.

If you are a real glutton for punishment, check out Clayton Paul's article "On the Superposition of Inductive and Capacitive Coupling in Crosstalk-Prediction Models" in the IEEE Transactions on Electromagnetic Compatibility (Vol. EMC-24, No. 3, August 1982). He shows that lumped circuit analysis gives significant errors for cases as small as 1/100 wavelength.

Attention Hams

Daryl has published two articles on EMC in *BEAM*, a new (free) ham radio magazine introduced in August 1990. These are: "Amateur Radio versus Microprocessors", Jul/Aug 1990 "Microprocessors versus Amateur Radio", Sept/Oct 1990. A future article on "DXing from (Almost) the North Pole" will describe his adventures on a consulting assignment last winter in Prudhoe Bay, Alaska — the wellhead of the Alaskan pipeline, and about as far north as one can go.

This free magazine is published by Tom and Jo Chesworth, who also publish *Electromagnetic News Report* (not free, but very worthwhile). For more information on either publication, call Tom or Jo in State College, Pennsylvania, at 814-466- 6559. And if you're an active ham, look for Daryl (K0FBF) on 10,12,15,17,20, and 40 meters.

Minnesota EMC Event

The Fifth Annual Minnesota EMC Event, jointly sponsored by Kimmel Gerke Associates and Amador Corporation, is history. A generous sprinkling of new exhibitors and session topics brought in many new faces, along with the regulars (who we always like to see at the Event.) The Thunderbird hotel was an excellent location, and we plan to use it again in 1991.

In addition to the Event, we offered two seminars, "ESD" and "Designing for EMC Compliance", on the two days preceding the Event. Out of town visitors particularly liked this idea, so we are planning a similar program this year.

Low Frequency Magnetic Fields

During the past year, we've seen an increasing concern in low frequency magnetic fields. Some are fueled by the controversy in the press on biological effects, while others are driven by equipment problems, such as "wiggling" CRT displays. Let's take a look at this issue, using the "Source-Path-Victim" model.

Sources. . .While any current carrying conductor has a magnetic field associated with it, the major concerns are 50/60 Hz fields (ELF) due to electrical wiring (transmission, distribution, facility), and the 15 KHz fields (VLF) due to the horizontal sweep in CRTs. The first area has prompted considerable research, and the second has resulted in the infamous Swedish magnetic field specs for CRTs.

Paths. . .Since low frequency fields are in the "near field", the fields diminish rapidly (as the inverse square or cube) with distance. Thus, if one anticipates problems, separating the source and victim is very effective! In fact, this should be your first line of defense in any low frequency field problem — just move things.

Victims. . .At this time, we've seen no reliable evidence that there is a significant health hazard to humans from either ELF (60 Hz) or VLF (15 KHz) fields in today's environment. We do know, however, that CRTs can be affected by 60 Hz fields, and we've even done some research on this ("60 Hz Magnetic Field Susceptibility Tests on CRT Displays", presented at the 1990 IEEE EMC Society Symposium in Washington DC. Call or write for a copy of this paper.)

Mitigation. . .Its very difficult to shield for low frequency magnetic fields — thick steel or high permeability materials are needed. On the other hand, source-victim separation, loop control, and wire twisting can be very effective. If you need design help, or if you need a magnetic field survey, give us a call.

A KGB Bullet. . .

Cable resonances are often responsible for radiation peaks. These resonances occur at multiples of 1/4 wavelength. The following table shows sample cable resonances.

Frequency	1/4	1/2	3/4	1
10 MHz	25 ft	49 ft	74 ft	98 ft
30 MHz	8 ft	16 ft	25 ft	33 ft
100 MHz	30 in	59 in	89 in	118 in
300 MHz	9 in	20 in	30 in	39 in
1000 MHz	3 in	6 in	9 in	12 in

Note: Exact lengths may vary slightly due to antenna effects.

Recent Projects

Our experience goes far beyond dealing with traditional EMI issues, such as FCC, VDE, and MIL-STD-461. Here are some recent projects on which we have helped our clients...

Design reviews — High speed/high performance systems

Medical products — ESD and RF susceptibility
Automotive products—emissions, ESD, MIL-STD-461, SAE

Military products — MIL-STD-461, TEMPEST

Computer systems — FCC, VDE, IEC 801 (European immunity)

Facilities — Shield room design, magnetic and electric field measurements, power disturbances

Training — FCC/VDE, ESD, immunity design, facilities, MIL-STD-461 design, power disturbances

Call us if we can help you. All inquiries and projects are treated in a confidential manner.

Expert Witness Help Available

Although we hope you and your products don't end up in court, we might be able to help if they do. We've both had experience as "expert witnesses", and although that is not a central part of our business, we do offer that as a part of our services as consulting engineers.

By the way, we limit our legal activities to helping defend our clients. . .you won't find us "chasing ambulances." We are both Registered Professional Engineers, which is almost mandatory in this area.

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Daryl Gerke, PE William Kimmel, PE
1544 North Pascal • St. Paul, MN 55108 • 612-330-3728

Kimmel Gerke Associates, Ltd.
1544 North Pascal
St. Paul, MN USA 55108
612-330-3728