KIMMEL GERKE Bullets

MEMBER AMERICAN CONSULTING ENGINEERS COUNCIL

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Welcome to KGB. . .

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

This issues focuses on automotive electronics, and the special EMC problems and constraints faced by designers of vehicular electronic systems. With the proliferation of electronics in the modern automobile, the potential for EMI/EMC problems proliferate as well.

The vehicular electronics designer is faced with severe EMI/EMC challenges. The environment is very rough, the constraints are very tight, and the solutions must be very inexpensive. Sometimes it makes one yearn for a "simple" FCC, VDE, or MIL-STD-461 problem to work on.

We've worked on quite a few vehicular projects, so we appreciate both the problems and the solutions. If you're involved with vehicles, we salute you...and if you're not, we hope you pick up an idea or two. When dealing with EMI/EMC, we all learn from each other, right?

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

Please Requalify. . .

Please return the enclosed card if you wish to continue to receive Kimmel Gerke Bullets. If you joined us or updated us since January, you can disregard. . . *unless you've 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. . . your name is never passed on.*

Shows and Conferences. . .

1991 International IEEE EMC Symposium. . . The annual IEEE conference on interference, held August 13-15 at the Hyatt Cherry Hill, Cherry Hill, NJ. We'll both be there...hope to see you there too.

Sixth Annual Minnesota EMC EVENT. . . The local (Twin Cities) EMC show of the year is coming up fast. Will be held again at the Thunderbird in Bloomington, October 24, as part of **Minnesota EMC Week**. In addition to the one day show, we'll again have in-depth seminars, plus a special IEEE EMC Society meeting. Watch for more information, and plan to attend.

EMC-Expo-91 A Success. . .

We really enjoyed attending and participating this show in Orlando in late June. Bill chaired the session *20 Common EMI Design Mistakes*, and Daryl chaired the session on *Power Disturbances*. Thanks to all of you who attended or participated in these sessions. We've heard that this show will return to Orlando next year in July, so if you missed this one, plan on next year.

Santa Clara Valley EMC 91. . .

It was a pleasure meeting many of you at this EMC colloquium in mid June. A really nice show with over 400 registrants. *Hats off to the Santa Clara Valley IEEE EMC Society for a very fine job!*

EMC Test and Design Magazine. . .

If you're not receiving this free magazine, you should be. It began last year, and is published bi-monthly by Cardiff Publishing. We think it's a nice magazine, with *outstanding* technical contributors (see the July/August 1991 issue for Bill's article *Electronics in Industrial Applications.*) Call 303-220-0600 for free subscription information.

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 Automotive/ Vehicular Electronics. . .

This issue focuses on automotive and vehicular electronics, and some of the special problems faced by designers in this area. With the proliferation of electronics in vehicles today, it's no surprise that EMI/EMC is a key concern.

We've worked on quite a few vehicular projects in the past several years. They've always been challenging, and we have a very high regard for our clients and colleagues working with vehicular electronics.

Vehicular EMC problems are affected by several factors, including a **harsh environment, severe constraints**, and **extreme sensitivity to cost.** Fortunately, there are industry guidelines that help define the requirements.

The **harsh environment** has several threats, including power transients, radio frequency interference (both to and from nearby or onboard transmitters and receivers), electrostatic discharge, and power line electric and magnetic fields. Since vehicles, by their very nature, can go almost anywhere, the worst case environments must be assumed. Even military environments often pale by comparison.

The vehicular designer is faced with very **severe constraints**. Electronic systems must be highly reliable—even a single failure over millions of vehicles may not be tolerated. Any system that can affect vehicle safety must be "fail-safe." Systems must be easy to test, install, and repair. And of course, all of this must be done at the **lowest possible cost!**

Here are some comments on each of the "EMC threats" faced by the vehicular electronics designer.

Power transients. . .Vehicle electrical systems are a rich source of transients. The most severe have been characterized, and have become a suite of standard EMC test pulses. SAE J1113 describes seven pulses that simulate both normal and abnormal conditions, including inductive loads switched off, ignition turn-off, ignition interruption, voltage drop during engine starting, and the alternator "load dump" transient.

These transients can damage or upset electronic systems. Digital circuits are particularly susceptible to transients, which can result in false triggering or "flipped bits." As electronic devices (such as microcontrollers) become smaller and faster, they become even more vulnerable to spikes.

The solution is to provide transient protection on module input power lines, plus backup protection at the circuit level. Software "fixes" can be particularly effective here.

Radio Frequency Interference (Susceptibility). . . Since vehicles are often a platform for land mobile radio transmitters, the on-board electronics systems may be exposed to very high electromagnetic field levels. As a rule of thumb, a 100 watt radio at 1 meter has an electric field intensity of over 50 volts/meter. Thus, test levels of up to 200 volts/meter are specified.

Typical failure levels for unprotected electronic systems are in the 1-10 volt/meter range. Low level analog circuits, such as sensors, are particularly vulnerable to this threat. They are driven into cutoff or saturation, and then rectify the radio frequency energy.

The solution here is to prevent the unwanted energy from reaching low level stages. This requires high frequency filtering on cables (which act as antennas), shielding, decoupling, and careful circuit layout.

Radio Frequency Interference (Emissions). . . Since almost all automobiles today have very sensitive AM or FM radio receivers (or land mobile VHF radios), emissions from digital circuits are a big problem. The problem is compounded since the circuits are often located close (within a meter) to the radio.

As a result, the limits imposed by the manufacturers are 60 dB or more stringent than comparable FCC/VDE limits. If these low levels can not be met, irritating "hash" or "birdies" may be heard on the AM/FM radio receivers. Thus, even though vehicular electronics are exempt from FCC testing, the exemption is often moot.

The solution here is to limit emissions by shielding, filtering, grounding, and careful circuit layout. Clocks (and other repetitive signals) must be controlled. Power decoupling is also very important (a small ferrite can work wonders here.) Keep in mind the objective is to be 1000 times more quiet than a personal computer (and 30 times more quiet than a military design.)

Electrostatic discharge. . . Since almost every vehicle has humans on board, and since humans are a ready source of ESD, this is a major threat to vehicle electronics.

An ESD event results in a very rapid pulse, with risetimes in the 1-3 nanosecond range. Pre-discharge voltages from humans typically reach 10-15 KV. Most automotive electronics are designed to withstand at least 15 KV.

continued. . .

A KGB Bullet. . .

Grounding of cable shields is a common concern. For "electrically long" cables, shields must be grounded at both ends; for "electrically short" cables the shield can be grounded at only one end. The accepted transition from "short" to "long" is 1/20 of a wavelength at the highest frequency of concern. For digital signals or transients, this frequency is about 0.3/(risetime.)

Frequency	60 Hz	10 KHz	1 MHz	100 MHz	1 GHz
Risetime	5 msec	30 usec	300 nsec	3 nsec	300 psec
$\lambda/20$	250 Km	1.5 Km	15 m	15 cm	1.5 cm

Focus on Automotive/ Vehicular Electronics. . . *(continued)*

At 1 nanosecond, the equivalent "bandwidth" is over 300 MHz, so ESD can be considered a "high frequency" issue. Because of these high frequencies, a "direct hit" is not necessary; the intense electromagnetic fields from a nearby hit can easily upset a system.

The solutions here are to limit damage by transient suppression on input lines, and to limit field coupling by shielding, decoupling, and careful circuit layout. Ferrites are particularly useful against ESD.

60 Hz Power Line Fields. . .Since vehicles can go almost anywhere, and since power lines (and transformers) can be almost anywhere, this threat must be addressed.

This is not usually considered a big problem for digital or analog circuits, since at 60 Hz, field coupling is not very efficient. Nevertheless, low level magnetic transducers can be affected by "stray" magnetic fields, and low level high impedance devices can be affected by "stray" electric fields. Thus, power line field requirements are typically imposed on vehicular systems.

The solutions are usually instrumentation oriented - shielding and filtering of the most critical circuits.

For more information. . .SAE J1113 (Electromagnetic Susceptibility Measurement Procedures for Vehicle Components) gives recommended test levels and procedures for automotive components. Each of the major automotive manufacturers have their own test limits and requirements that are imposed on their suppliers. Other vehicular companies often have their own requirements as well.

We've written several papers in this area - two on vehicular RFI (VHF Radios and Microprocessors - Mutual Antagonists - Parts I and II) and one on software (Designing Microcomputer Systems to Tolerate Noise, SAE 870787.) Call if you'd like copies.

The bottom line. . .Automotive/vehicular EMI/EMC limits are tough to meet. The equipment lives in a tough environment, and there are tough constraints. Nevertheless, with careful EMI/EMC design these requirements can be satisfied.

Book Reviews. . .

Here are two books on analog design that we really like. No, they are not strictly about EMI, but they do address many types of problems faced by analog designers, including EMI.

Troubleshooting Analog Circuits, by Bob Pease of National Semiconductor. This is a reprint of Mr. Pease's excellent series of articles that appeared in *EDN Magazine*. Lot's of good technical information, and very easy and enjoyable to read. Published by Butterworth/Heinemann.

Analog Circuit Design, edited by Jim Williams of Linear Technology. This is a collection of "essays" on analog design, with articles by Jim, Bob Pease, and other notable names in analog design. Also easy and enjoyable to read. Published by Butterworth/ Heinemann.

If you're really into EMI and sensitive analog circuits, your library should also include **Grounding and Shielding Techniques in Instrumentation**, by a friend and colleague, Ralph Morrison of Instrum. Published by John Wiley and Sons.

Power Line Magnetic Fields. . .

We continue to get calls for the problem of "wiggling" CRT displays due to 60 Hz magnetic fields. The problems are usually caused by **external** adjacent transmission lines (100 feet or less away) or **internal** transformers or wiring/bus bars (1-20 feet away).

If you're having problems with this, give us a call. We've conducted tests and written papers on the subject, so we understand the issues. We also own a Holaday Magnetic Field survey meter, so we can perform measurements if needed.

Here are the two papers we've written:

- *Power Line Magnetic Fields and CRTs - An Emerging Power Problem*, presented at EMC-EXPO-1991, Orlando, Florida, (June 1991)
- *60 Hz Magnetic Field Susceptibility Tests of CRT Displays*, co-authored with Paul Cook of AMADOR and presented at the 1990 IEEE EMC Conference, Washington, DC (August 1990).

Call or write for free copies of either or both papers.

Professional Credentials. . .

As consulting engineers, we are often asked about our credentials. Here are two that are quite relevant:

Certified EMC Engineers. . .We are both certified by NARTE (National Association of Telecommunications Engineers) as Certified Electromagnetic Compatibility Engineers. This credential is important to government contractors, as it was established by the US Navy to assure that EMC engineers have adequate knowledge, proficiency, and experience with EMI and EMC issues.

Registered Professional Engineers. . .We are both registered as Professional Engineers (PE), licensed to practice as electrical engineers. This credential is important to power utilities, telephone companies, architects and engineers involved with public safety. It's also important to attorneys, if they need our services as "expert witnesses".

Minnesota EMC Week
October 21-25, 1991

Mark your calendars to join us this fall for these EMC activities. Learn new techniques, see new products, meet new people, and have a good time during **Minnesota EMC Week.**

Tues., Oct. 22	**Special IEEE EMC Meeting** Dinner and social hour
Tues., Oct. 22	**Full Day Seminar** "Design for EMC"
Wed., Oct. 23	**Half Day Seminars** "EC-92 EMC Update" "MIL-STD-461/462 Testing" "EMC For Medical Devices" "Electrostatic Discharge Design"
Thurs., Oct. 24	**SIXTH ANNUAL MINNESOTA EMC EVENT.** Over 30 vendors plus half-hour tutorial sessions on design, test, and products. (FREE to Preregistered Attendees)

All events held at the Thunderbird Hotel, Highway 494 and Cedar in Bloomington, Minnesota. New things to see and do.

Courses Available. . .

If you'd like instruction on how to design and/or install your equipment for EMI compliance (FCC/VDE) or immunity (ESD, power, RF, etc) we can help with one, two, three, or four day classes. Available either "off the shelf" or "custom designed."

If you need to train five or more people, an in-plant course can probably save you money. And since the class is taught by an experienced EMI consultant and instructor, you get practical up-to-date knowledge, not a lot of theory. Call us at 612-330-3728 for details and pricing.

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