From September 2008 *High Frequency Electronics*




## Some Notes on Electromagnetic Compatibility (EMC)

The recent IEEE EMC Symposium was a reminder of the importance of design in both regulatory compliance and reliable operation of electronic equipment. Here are a few reminders of causes, effects, and methods of dealing with EMC problems.

*1. Cables can become antennas*—Compliance testing requires a typical installation, including interconnecting cables. Problems that were not apparent in individual modules may suddenly become evident. Give extra attention to the techniques below when dealing with the portions of the circuit around connectors.

*2. Look out for box resonances*—Rack mount instruments and desktop PCs have metal enclosures that are large enough to be resonant at typical clock frequencies in the 100s of MHz. These resonances can enhance radiation or create a severe response to immunity tests, especially if the resonance is close to one of the unit's clock frequencies.

*3. Don't forget the DC circuits*—proper decoupling and isolation of DC power distribution is essential. Many troublesome EMC problems have been traced to the DC path, including crosstalk and excess radiation.

*4. Bypass capacitors*—A whole book could be devoted to this subject. Get familiar with the concepts of ESR (effective series resistance) vs. frequency, SRF (self-resonant frequency), and the effects of multiple capacitors in parallel, distributed along the power bus and ground plane.

*5. There is no perfect "ground"*—large areas of printed circuit board copper have low impedance, but it's not perfect. Digital signals that swing 3.3V or 5.0V are very large AC/RF sources. They will induce currents in the ground plane that are not uniform. Electromagnetic modeling will expose some problems, but there is no substitute for experience gained through experiment and analysis. There are some fairly simple principles concerning RF currents on a conducting sheet that are a good start. Review your first semester Electromagnetics textbook!

Now we can discuss the active electronics...

*6. All clocks are little RF transmitters*—Actually, they are not so small: $3.3V_{p-p}$ across 50 ohms is in the 100 mW (+20 dBm) range. Containing this energy within the circuit requires proper transmission line design of signal traces, including their dimensions, routing, termination, and relation to the ground plane.

*7. Board layout is critical*—In addition to the things noted in [6], crosstalk between signal paths can corrupt digital waveforms, as can excessive reflections from poor terminations or discontinuities. These effects increase rapidly at frequencies above about 400 MHz, where typical board dimensions are a large fraction of a wavelength. This is why there is so much current attention to "signal integrity"—today's GHz+ clock and data rates require microwave circuit techniques to achieve reliable operation.

*8. Know when to use shielding*—Shielding is often used as a "fix" for EMC compliance problems. It is best practice to anticipate where shielding may be required, using both analytical modeling tools and design experience. Then, when the need arises, the layout may already accommodate the placement of a shield to reduce radiation to acceptable levels.

*9. Identifying self-interference*—Troubleshooting "glitches" or other functional failures can be difficult and time consuming. They may even appear after careful attention has been given to the preceding 8 items on this list. Most troubleshooting begins by tracing operation from input to output, isolating the problem area. Once the general location is identified, the circuit can be examined for layout problems that cause crosstalk via signal, power or ground traces. Direct radiation or couple between mounted components is also possible.

*10. EMC immunity*—Although U.S. consumer electronics do not generally have an immunity requirement, the EU and all products for military use must meet immunity standards. The good news is that design practices that reduce radiation will also improve immunity. Conversely, products designed with immunity as a high priority (e.g., shipboard military application) will also be robust from a radiation standpoint.

Immunity requirements were initially concerned with nearby broadcast and other high power electronics, but with explosive growth in wireless devices of all kinds, RF transmitters with a wide range of frequencies and field intensity levels are commonplace. Immunity performance has become essential for coexistence of all types of electronic devices.