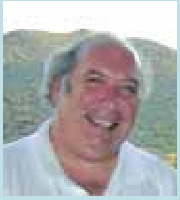

Design Tips

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Welcome to Design Tips! If you attended the IEEE EMC Symposium in Detroit, most likely you noticed the many different software companies with tools now available for EMC engineers to help predict EMC performance of products before they are built. This article is intended to help readers make sense of the ton of information that was available from the exhibitors. Many of these tools are excellent, but the buyer must understand what the tools can really do (and what they can NOT do)!

Please send me your most useful design tip for consideration in this section. Ideas should not be limited by anything other than your imagination! Please send these submissions to bruce.arch@ieee.org. I'll look forward to receiving many "Design Tips!" Please also let me know if you have any comments or suggestions for this section, or comments on the Design Tips articles.

There is No Such Thing as a Free Lunch

Tight schedules, budgets and higher speed devices have made EMC software tools more attractive than ever before. Radiated emissions are always a challenge, and the lower voltage levels of very high-speed devices mean that that immunity (ESD, radiated, conducted) has become even more important than in the past. Certainly there will be no shortage of work for EMC engineers in the near future!

However, there is actually a shortage of trained/experienced EMC engineers. Many companies do not have a full time EMC engineer (if they have any at all), or if there is an EMC engineer, he/she might be relatively inexperienced.

This means that product designers are looking for help to replace the shortage of experienced EMC engineers and software tools seem to hold great promise. In recent years, many companies have created software tools to help with EMC design. Companies will often claim that their tools can do PCB-level analysis through system-level analysis, and they will have very impressive color 3D plots to 'prove' it. However, the phrase 'there is no such thing as a free lunch' has new meaning in this context. The tools *can* do some things very well, but they cannot replace the need for experienced EMC engineers, basic knowledge of electromagnetics, and knowledge of the various simulation techniques' strengths and weaknesses. (Actually "free lunch" might not be the best phrase…these tools can cost $20K-$80K and even higher.)

A wide range of automated EMI/EMC tools is available to the engineer. Automated tools include design rule checkers that check printed circuit board layout against a set of predetermined design rules; quasi-static simulators, which are useful for inductance/capacitance/resistance parameter extraction when the component is much smaller than a wavelength; quick calculators using closed-form equations calculated by computer for simple applications; full-wave numerical simulation techniques which will give a very accurate simulation for a limited size problem; and expert-system tools, which provide design advice based on a limited and predetermined set of conditions. It is clear that these different automated tools are applied to different EMI problems, and at different times in the design process.

Automated EMC Design Rule Checking

The EMC performance of a printed circuit board is mostly based on the location of the various components and the location of the various critical high speed and I/O nets/traces. Manual checking of all the various layers of today's high speed circuit boards is too time consuming and prone to human error. Automated rule checking software relieves the tedium and removes the human error by reading the CAD design file, taking each critical net/trace in turn, and checking that it does not violate any of the most important EMC design rules.

The usefulness of this kind of tool is largely based on the EMC design rules and whatever limits are used for each of the various design rules. Naturally, for different types of industries, some of the design rules will vary, so it is important that the automated design rule checking software allow creation of customer or industry specific rules.

There are many EMC design rules available from many sources. Many of these EMC design rules are in conflict with one another. So a user might reasonably ask, "Which rule is right for my products?"

Some of the automated EMC design rule checking software implement rules that are based on more detailed laboratory testing and/or fullwave simulations. Each rule should be based on solid electromagnetic physics and not on 'faith'. Users should be very cautious before accepting EMC design rules. These rules should not only have detailed justifications but make sense with the basic fundaments of physics. Just because a rule might be 'commonly accepted' does not mean it is right for every product or industry. Remember, it was not very long ago when it was commonly accepted that the earth was flat!

Fullwave Electromagnetic Simulation Software

Today's fullwave EM simulation software tools cannot do everything. That is, they cannot take the complete mechanical and electrical CAD files, compute for some limited time, and provide the engineer with a green/red light for pass/fail for the regulatory standard desired. The EMI and/or design engineer is needed to reduce the overall product into a set of problems that can be realistically modeled. The engineer must decide where the risks are in the product design, and analyze those areas.

Company claims must be carefully examined. Companies might claim to allow an engineer to include detailed PCB CAD designs along with metal shielding enclosures to predict the overall EMI performance. However, these tools are not really capable of such analysis. There are too many things that will influence the final product to make such a prediction with any level of accuracy. Yet these full wave simulation tools are extremely useful to help the engineer analyze specific parts of the design in order to better understand the physics of the specific feature under study. Then the engineer can use this knowledge to make the correct design decisions and trade-offs.

Tool Box Approach is Required

No single modeling/simulation technique will be the most efficient and accurate for every possible model needed. Unfortunately, most commercial packages specialize in only one technique, and try to force every problem into a particular solution technique. The PCB design engineer and EMI engineer have a wide variety of problems to solve, requiring an equally wide set of tools. The “right tool for the right job” approach applies to EMI engineering as much as it does to building a house or a radio. You would not use a putty knife to cut lumber, or a soldering iron to tighten screws, so why use an inappropriate modeling technique?

Quasi-Static Simulation Software

When an object is electrically very small (compared to the wavelength of the highest frequency of interest) then quasi-static simulation tools can be used. The fundamental assumption is that there is no propagation delay between elements within the model.

Quasi-static tools are very useful for creating an equivalent circuit of inductance, capacitance and resistances that can be solved with circuit solvers, such as SPICE. Matrices of many elements can be used for including complex PCB connectors in signal integrity simulations.

Other Software Tools

There are a wide variety of software tools available to do specific tasks. The user must carefully consider if the software tool will do the type of analysis that is required. For example, some companies offer simulation software that will read complete CAD files, and then predict the far field emissions level based on the simple loop formed by a microstrip and the return/ground plane. This simplifying assumption is too simple for most applications, since the far field emissions are most often directly controlled by the metal shield (and the openings) as well as long attached wires, and not directly from the traces on the board. While the traces on the PCB might be the initial cause of the emission, the coupling to other features, since the metal shield and/or cables is the dominant effect. This dominant effect is ignored by these tools and therefore can lead to dangerous and disastrous decisions when used incorrectly.

Know the Software Tool’s Assumptions!

Just as it is important to know the limitations of the simulation techniques, it is important to know and understand the basic assumptions the company has used in the specific software tools. Many times the important factors are not displayed to the user (so the tool looks easier to use and less confusing). However, these factors can have an enormous impact in the accuracy of the final results. Always remember: “The tool will give you a very accurate answer to whatever question you ask it, even if the question is wrong!”

Proper Simulation Validation

In the early years of EM simulation, the practitioners were experts in EM theory and simulation techniques who often wrote their own programs to perform the simulations. However, modeling and simulation is no longer restricted only to experts. The commercially available codes are diverse, easy to use, and provide the user with convenient means to display results. New users can begin using these codes quickly without the requirement of being an ‘expert’.

The danger that is not highlighted by companies or creators of simulation software is the need to validate the simulation results. It is not sufficient to simply ‘believe’ a particular software tool provides the correct answer. Some level of confidence in the results is needed beyond a religious-like trust in a software tool simply because others use it, because the company assures their customers of the tool’s accuracy, or because others have validated their results in the past.

Summary

Many different software tools are available for PCB designers to aid in meeting EMI emissions and immunity requirements. There is no one tool that can do everything, and multiple tools, often at different complexity levels, are required.

Automated EMI rule checking tools can provide quick and specific analysis of PCB CAD designs, while more complex full-wave simulation tools can provide a very accurate and fundamental understanding for limited portions of the overall PCB and/or system. EMC