Computer Modeling Tools for EMC

T. H. Hubing and J. L. Drewniak
Electromagnetic Compatibility Laboratory
University of Missouri-Rolla

Abstract

Computer modeling tools for EMC analysis generally fall into one of three categories: numerical modeling codes, analytical modeling codes, or design rule checkers. Although these tools can be very helpful to the experienced EMC engineer, computer modeling tools are rarely used to analyze or prevent EMC problems during the development phase of new products. This paper discusses computer tools that are currently available and introduces a new class of EMC modeling software based on an expert system approach.

Introduction

There are a number of computer modeling codes available to EMC engineers and circuit designers today. Computer modeling tools can be used to provide information about a particular design that is not readily obtained in any other manner. For example, computer modeling tools can calculate values of parasitic inductances and capacitances in a circuit, model the behavior of the radiated fields, determine current distributions, calculate crosstalk, evaluate the effectiveness of a shielded enclosure, or locate simple design mistakes.

Generally, software tools for EMC analysis fall into one of three categories: numerical modeling codes, analytical modeling codes, or design rule checkers. Numerical modeling codes analyze problems by numerically solving Maxwell's equations subject to particular boundary conditions. Analytical modeling codes use closed-form equations and/or pre-calculated solutions to analyze EMC problems. Design rule checkers scan a printed circuit board or system design for errors or violations of EMC design guidelines without attempting to calculate fields or currents.

Numerical Modeling Codes

Numerical electromagnetic modeling software is widely viewed as a promising new tool to help EMC engineers and circuit designers anticipate electromagnetic compatibility problems. Numerical EM modeling codes solve field equations subject to appropriate boundary conditions in order to determine the electromagnetic behavior of different source configurations.

The ability of a numerical modeling code to model a particular geometry is largely dependent on the numerical technique employed by the code. Finite element modeling codes (e.g. MSC/ EMAS or AnSoft's MAXWELL codes) excel at modeling relatively complex geometries with lossy or even nonlinear materials. Codes that employ surface integral techniques (e.g. NEC, COMORAN, HFSS, EM, IE3D, COMPLIANCE, MAXSIM-F) are very well suited for modeling relatively large, resonant structures; particularly structures with long wires or cables. Finite difference time domain (FDTD) codes (e.g. XFDTD, EMA3D, EMIT) are usually the best choice for time domain or broadband modeling.

Ansoft, Cadence, Hewlett-Packard, Quad Design, and Quantic Laboratories have packaged numerical modeling software with software that automatically extracts printed circuit board geometry data from automated board layout tools. These tools make it easier for EMC or signal integrity engineers to take advantage of numerical modeling software. INCASES (EMC Workbench) and Seth Corporation (EMIT) have developed software environments that bring together a variety of numerical modeling tools with a common interface designed specifically for EMC engineers.

Despite the availability of software that models geometries of interest to EMC engineers with a high degree of accuracy, numerical codes have not been widely utilized for EMI modeling. Only a small percentage of EMC engineers use numerical modeling codes on a regular basis. One reason for this is that numerical codes require well defined sources. Defining the source of an EMC problem is often the most difficult step in the solution process. When an EMC engineer can identify the parameters necessary to do a numerical analysis (i.e. source location, source amplitude, and antenna geometry), then often the problem can be corrected without doing a numerical analysis. Numerical electromagnetic modeling codes are sometimes used to analyze specific circuits or structures, but typical printed circuit board configurations are much too complex to be analyzed in their entirety using strictly numerical methods.

There is an additional problem with existing numerical EM modeling codes that often prevents them from being used, even in cases where relatively simple well-defined model geometries can be identified. Existing modeling codes have a fairly steep learning curve. The user must be reasonably well versed in the procedures for applying the code as well as the techniques used by the code and their limitations. Few EMC engineers can afford to be an expert user of several EM modeling codes that may or may not be occasionally helpful. Numerical EM modeling codes are potentially a very valuable tool for EMC problem analysis, but in their present form they require too much expertise on the part of the user to be widely used as an EMI modeling tool.

Analytical Modeling Codes

Analytical modeling software, which uses relatively simple closed-form expressions to calculate parameters such as field strengths or currents tends to be much faster and a little easier to use. Analytical methods fit problems to pre-defined geometries with known solutions. IEMCAP is one relatively well known example of a code based primarily on analytical techniques. Analytical modeling codes for EMC engineers are also marketed by Interference Control Technologies, Kimmel Gerke Associates, CKC Laboratories and Atkinson Engineering. Each of these codes is much faster and easier to use than a general purpose numerical modeling code, however each code has a limited set of functions that it performs.

Although analytical modeling codes tend to be easier to use than numerical modeling codes, the user must still be aware of assumptions that the code is using and limitations imposed by these assumptions. Learning to use the code is not the same as learning how and when to apply the code.

Like numerical modeling software, analytical modeling codes rely on the user to define sources and other critical parameters. Identifying these parameters requires a certain amount of EMC knowledge. There is little value in performing a highly accurate analysis of an incorrect model.

Rule Checking Codes

EMC rule checking software reads board layout information from automated board layout tools and looks for violations of basic EMC design rules. This type of software does not usually attempt to predict the electromagnetic behavior of the system, but instead is intended to help designers avoid costly mistakes early in the design stage. Cadence markets an EMC design rule checker under the name DF/EM Control. Zuken-Redac has a design rule checker called EMC Adviser. These tools can help board designers to locate potential problems with their designs and they can also help experienced EMC engineers to quickly identify problems that would otherwise be hard to spot.

Unlike numerical and analytical modeling software, rule checkers do not require the user to understand basic principles of electromagnetic modeling. However, the available rule checking codes do require the user to identify critical nets and supply information about the signal parameters. This requires a certain amount of expertise on the part of the user, but it is a different kind of expertise. Another difficulty with rule checkers is that design rules and their impact on EMC can vary significantly from one design to another. Design rule violations that are a major problem for one design may be of little consequence in another design.

Expert System Codes

Although each of the techniques above can be a very powerful tool in the hands of a knowledgeable user, software employing these techniques is not widely used by EMC engineers or circuit designers. The learning curve associated with available tools is often too steep. Few engineers have the knowledge and experience required to use these tools effectively.

To circumvent this problem, a new class of EMC software is currently being developed at a number of laboratories around the world. This new class of software attempts to emulate the thinking process of experienced experts in EMC. EMC engineers rely on design rules, but when a rule is violated, they perform a quick analysis of the overall design to evaluate the impact of that rule violation. EMC engineers may take advantage of numerical and analytical modeling tools, but only after the critical parameters of the problem have been identified. Software that works like this is appropriately classified as expert system software rather than numerical, analytical, or rule-checking software.

EMC expert system software seeks information from a variety of sources. By definition, expert system software does not assume a high level of expertise on the part of the user. Like an EMC expert, the more information the software has about a particular problem, the more effective its analysis will be. Nevertheless, even with incomplete information, expert system software attempts to provide a helpful and accurate EMC evaluation of a design.

Conclusion

There are a number of software tools that can help product developers to meet their EMC requirements. Modeling codes that employ numerical, analytical or rule checking techniques can analyze a wide range of EMC problem geometries and are readily available. To the experienced user, these codes can be valuable EMC design tools.

EMC expert system codes won't eliminate the need for other types of EM modeling codes, but they will play a significant role in the future of EMC engineering. By emulating the thought processes and techniques used by EMC engineers, EMC expert system codes will zero in on the most significant features of a design from an EMC standpoint. EMC expert system software promises to identify and evaluate EMC problems faster and more accurately than existing modeling codes. Also, because expert system software does not require any expertise on the part of the user, circuit designers, board layout personnel, EMC engineers, technicians and others can use the software to evaluate a product at different stages in the design process.

Companies with Software Products Mentioned in this Paper

Ansoft Corporation (Maxwell)
Phone: 412-261-3200
WEB: http://www.ansoft.com

Bay Technology (IE3D)
Phone: (408) 688-8919
WEB: http://www.bay-technology.com/

ElectroMagnetic Applications, Inc. (EMA3D)
Phone: (303) 980-0070

HP EEsof (HFSS)
Phone: (415) 964-2456
WEB: http://www.tmo.hp.com:80/tmo/hpeesof

INCASES North America Inc. (EMC-Workbench)
Phone: 214 373 7344
Fax: 214 373 7784

MacNeal-Schwendler Corporation (MSC/EMAS)
Phone: (414) 357-8723
WEB: http://www.macsch.com

MATRA-MARCONI (MAXSIM-F)
Phone: (+33) 61.39.65.12
Fax: (+33) 62.24.77.90
email: estienne@maxwell.matra-espace.fr

Quad Design Technology (QUIET)
Phone: (805) 988-8250

Quantic Laboratories (Compliance)
Phone: (800) 665-0235

Remcom Inc. (XFDTD)
Phone: (814)-353-2986
WEB: http://www.remcominc.com

SETH Corporation (EMIT)
Web: http://www.sethcorp.com

Sonnet Software Inc. (EM)
Phone: (315) 453-3096
Web: http://www.sonnetusa.com