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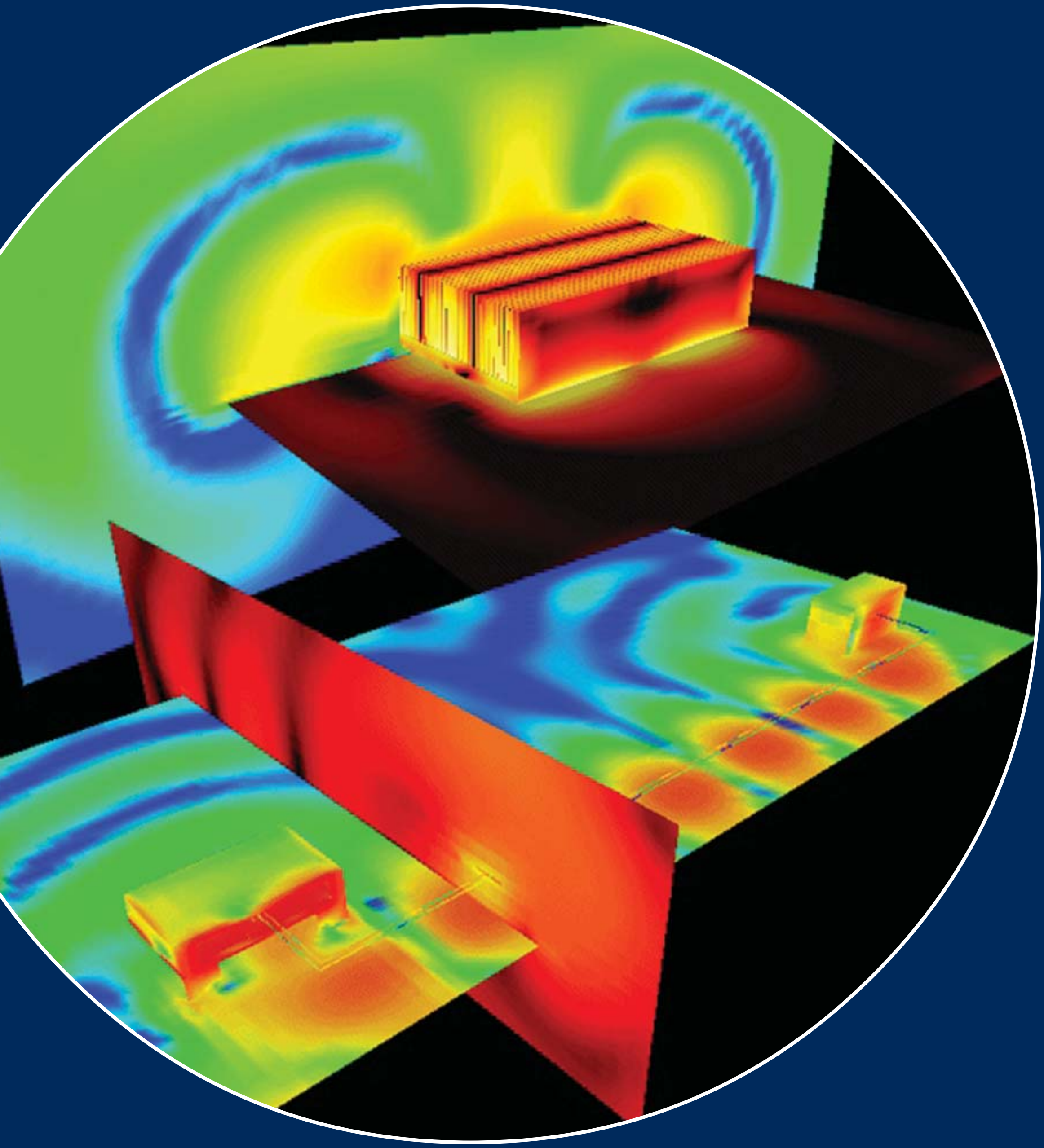

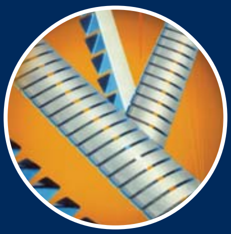

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Choosing Software for EMC Simulation

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Designing electronic products to meet EMC requirements is becoming more and more challenging. Faster clock speeds and lower operating voltages are leading to enhanced emissions via apertures and seams, from heat sinks as well as an increase in the susceptibility of products. In addition, the trend towards integrating multiple wireless capabilities into products makes it necessary to also deal with the electromagnetic interference (EMI) effects of intentional radiators.

These, and other, ever-increasing challenges are testing the limits of conventional EMC design methods. The rules of thumb, best-practice techniques and experience that are commonly used during the design process often fail to work at higher frequencies. The result, in many cases, is that the design then fails when first tested. This leads to additional time and resources being spent on redesign and retesting. The cost of a comparable design change typically increases by several orders of magnitude as the design moves through the development stages from concept, to detailed and, to validation. So, expensive late-stage fixes are often the only option available when EMC problems are not discovered until the prototype phase. The need to change the design, and re-test the product, may also cause the product to be delivered late, which can reduce the revenues generated by the product over its lifecycle.

For these reasons, amongst others, many designers of electronic products have incorporated EMC simulation into their workflow and many others are looking at doing so. At first sight, EMC simulation can seem complex and many may not know what to look for when investigating the tools available on the market. This article aims to highlight some of the key aspects that should be considered when looking to incorporate EMC simulation into the design process.

Methods of Predicting EMC performance

There are three basic approaches to predicting EMC performance, which can be used either independently or in combination with each other.

The first and simplest approach consists of rule checkers that work in conjunction with, or are built into, electronic design automation (EDA) systems. Rule checkers are designed to automate the rules of thumb that have been used for many years in an effort to design EMC compliance into products. Examples of typical rules include minimum spacing for traces and vias. The limitation of rule checkers is that they do not take the board geometry or the EMC source into consideration. As such, they provide only a rough approximation of the EMI potential. The result is that many designs which comply with all of the rules may fail EMC testing. In other cases, designers may need to intentionally violate rules to meet other design requirements.

A more sophisticated alternative is provided by tools that simulate electromagnetic emissions in 2D at board level. These software packages are typically designed to work directly with the design information produced by the layout tool. They solve Maxwell's equations to provide a physics based assessment of emissions in the immediate area of the board. These tools are primarily used for evaluating the signal integrity of the PCB but can also be used in the EMC design process through their ability to estimate near-field emissions from the board. While near-field emissions represent only one aspect of EMC design, they can be very useful for identifying the radiation from the board because much EMC mitigation takes place at the board level. However, even though through the use of 2D board level tools the emissions from the board may have been minimised, when placed into the system, there can still major issues due to coupling from the board to the system itself.

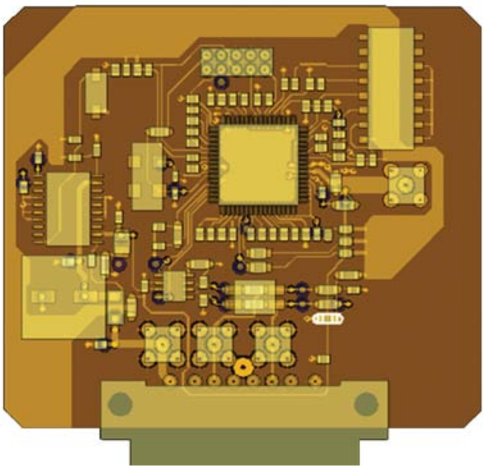

Figure 1: Typical model for a 2D board-level EMC simulation

The third approach is to perform a full 3D simulation of the system. This provides a comprehensive approach to EMC design by taking both the electromagnetic sources and the shielding provided by the enclosure into account in estimating the emission of the product. 3D EMC simulation provides some major challenges, the greatest of which is the aspect ratio of typical EMC simulation problems. A typical design includes an enclosure that is very large relative to features such as holes, slots, and cables - all of which are important to the EMC performance of the system. Accurate modeling requires that both large and small details be included in the model, which creates the challenge of building a model that can be solved in an acceptable period of time. Further adding to the computational challenge is the fact that electromagnetic field simulations must be performed over a wide range of frequencies.

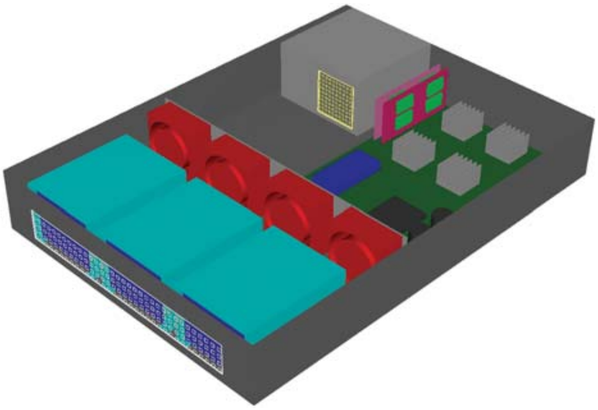

Figure 2: Typical model for a 3D system-level EMC simulation

System-Level Simulation Applications

System-level simulation software enables design and optimization at the system level to compute broadband shielding effectiveness, broadband radiated emissions, 3D far-field radiation patterns, cylindrical near-field radiated emissions (to mimic a turntable type measurement scenario), as well as the ability to visualize current and E and H field distributions, that help to locate EMC hot spots. Typical system-level EMC applications include: designing enclosures to ensure maximum shielding effectiveness; assessing the EMC ramifications of component location within an enclosure; computing cabling coupling, both internal and external to the system; and examining the effects of radiation from the cables. EMC simulation also helps identify specific mechanisms for unwanted electromagnetic transmissions through chassis and subsystems such as cavity resonances, radiation through holes, slots, seams, vents and other chassis openings, conducted emissions through cables, coupling to and from heat sinks and other components, and unintentional wave guides inherent to optical components, displays, LEDs, and other chassis-mounted components.

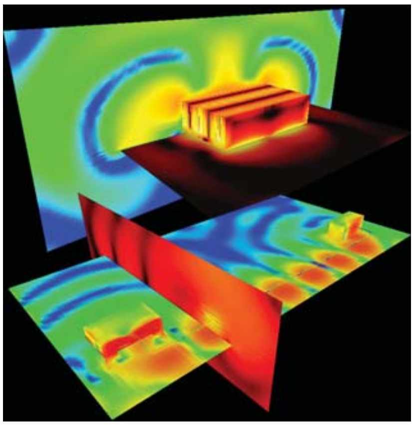

Figure 3: The ability to visualize the surface currents, electric and magnetic field distributions at different frequencies, gives designers added insight into the EMC characteristics of the system, allowing them to identify the cause of unwanted emissions.

Simple, fast-running enclosure models can be used to perform design tradeoffs of different design configurations such as the overlap of a seam, number of fixings along its length, or the design of a ventilation panel. By comparing the relative shielding and/or emissions levels provided, engineers can make an intelligent design decision based on the EMC budget for the enclosure and the cost of implementing a particular design. While there are rules for designing air vent panels for EMC leakage, EMC simulation allows more exotic configurations, such as back-to-back panels with large holes, waveguide arrays, etc. to be analysed while keeping other requirements such as airflow and cost in mind. Adding additional internal components to the simulation has only a small effect on simulation time so the designer can easily assess the enclosure shielding in a very realistic environment, accounting for the coupling between slot resonances, cavity modes, and the interactions with internal structures, all of which are not taken into account by basic design rules and, which can lead to costly over- or under-designing.

With increasing operating frequencies, the heatsinks and heatpipes placed on top of the major processors for cooling purposes are becoming electrically significant. As such, the EM fields being generated by the processors couple more efficiently to these devices than previously, and in turn, they start to act more like antennas and will unintentionally radiated these fields. Through the use of EMC simulation, it is possible to study multiple design configurations such as the number and type of fin used, their size, shape and grounding strategy.

Modeling Radiation Sources

The first step in 3D EMC simulation is modeling the radiation sources within the system. Direct modeling of all the sources in complete detail is computationally very intensive. One way to deal with this is to include only the most troublesome source or sources in the simulation. The most challenging signal or signals may be known either from previous experience, board level simulation, or from physical testing. In such cases, these signals can be modeled directly in the 3D simulation. In cases where it is not known which signals may be problematic there are several alternatives. The ideal solution would be to incorporate the model of the board into the full system model so that it computes both the emissions and effects of the shielding. The problem with this approach is that current computing systems are not powerful enough to solve a model this complicated in a reasonable period of time.

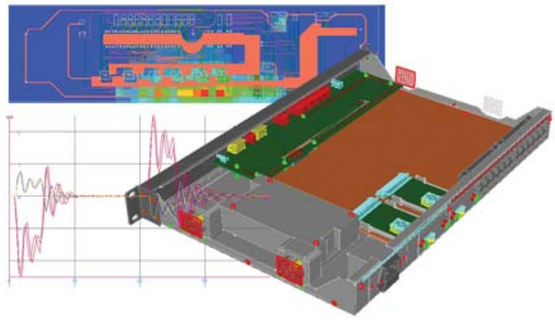

Figure 4: Scans, board-level simulations and measured waveforms can provide sources for a more accurate system-level EMC model.

A far less computationally intensive approach is to use board-level simulation to compute the near-field emissions and incorporate them into the full 3D systems model as boundary conditions. This approach is much less computationally intensive because the use of the near-field emissions eliminates the need to perform detailed computations at the board level. The challenge in this approach is providing the interface between the results from the board-level simulation and the system-level model. This has been accomplished through the introduction of a compact source interface that allows models of PCBs and other sources to be used in a system-level model.

Compact source models can be created by PCB specific analysis tools such as PCBMod from SimLab, Speed2000 from Sigrity or CST PCB STUDIO from CST and from measurement systems such as EMSCAN or Detectus.

Usability is a Critical Factor

As EMC simulation, at many companies, increasingly becomes an integral part of the design process, it's essential to know how to evaluate and select EMC simulation software that can have the most beneficial impact in bringing compliant products to market faster. Usability is a critical factor in selecting any design tool because if the software is not easy to use the chances are that it will gather dust on the shelf. Electromagnetic radiation is a very complex physical phenomenon whose study has traditionally been limited to analysts who have spent years studying the subject. Many general purpose EM software tools are still built around the requirements of such individuals in that they require users to have a substantial theoretical understanding of electromagnetic radiation in order to, for example, apply proper mesh densities and boundary conditions.

The latest EMC focused simulation software tools, on the other hand, have greatly simplified the analysis procedure by providing tools that enable users to accept design geometry and boundary conditions through interfaces to the other software that may already be used to define and analyze the design. These new simulation tools greatly simplify the modeling process by providing parametric library elements that can accurately represent design features that are significant from an EMC standpoint, such as PCBs, wires, perforated plates and slots and seams. These elements greatly reduce the time and expertise required to generate the model and also reduce computational time, whilst maintaining the accuracy of the solution.

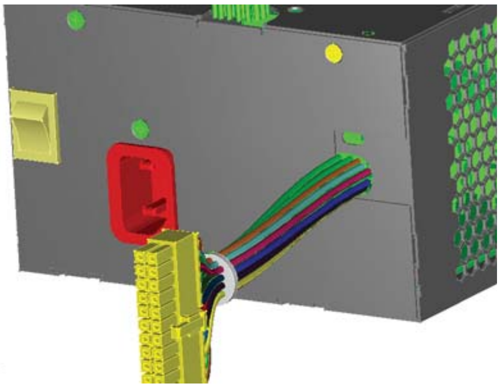

Figure 5: Geometrically small but electrically important features such as wires, vents, slots/seams and thin conductive films can be modeled with library elements.

Grid Generation Tools

In the past, simulation users faced a difficult choice of making their entire model relatively fine, which provided high accuracy but took a long time to run, or relatively coarse, which ran quickly at the expense of accuracy. This problem has been overcome in recent years by the innovation of localized gridding methods that enable the creation of fine grids in areas that need it while keeping grid density coarse in less important areas. While most software packages offer the ability to create localized grids, several new features have been developed recently to increase the power of the process. These features substantially improve multigridding capabilities by adaptively populating the mesh based on geometric characteristics. For example, the software will apply a coarse mesh in open regions while placing a fine mesh in areas with a high field gradient, such as small holes. Another gridding improvement is the ability to represent the ground plane in a test chamber or external environment without the need to mesh the area between the system and the ground plane. The proper size of the bounding box around the structure used to establish grid boundaries is automatically computed.

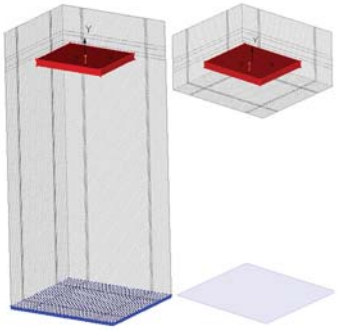

Figure 6: Including the effect of a ground plane can be important and, by being able to place it and the necessary field probes outside of the computational volume, leads to a much more efficient simulation than if the entire volume needed to be meshed.

Software Support is Key

A final, but critical, concern in evaluating EMC simulation software is the technical support provided by the software vendor. These modeling tools are not cheap but part of what you are buying is access to the vendor's technical support and the expertise of their engineers. These support engineers should not only understand how to operate the software but should also have experience with EMC design issues so that they understand the issues being faced and are able to provide practical assistance in solving EMC design problems. By asking the software vendor about the support services which they provide, and by talking with the engineers, you will be able to gauge the size of the support team and be able to check on their EMC expertise and experience.

Conclusion

Over the last 10 years, EMC simulation software has developed and matured significantly. While those new to the subject may see using EMC simulation as a daunting and complex challenge best left to the preserve of theoretical analysts, the reality of the situation is very different. EM software is becoming widely accepted as a vital part of the electronics design process.

In this article, I have briefly highlighted some of the different software based approaches to EMC simulation. While having concentrated on some of the aspects to consider when looking for a 3D modeling solution, it is worthwhile pointing out that the use of board-level EM solutions is growing and their output can be used to drive 3D simulations. The same is true for EMC issues associated with complex cable configurations. All of this work is leading to comprehensive solutions becoming available to engineers, allowing them to tackle EMC design issues with increased confidence, earlier in the design process.

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