

Getting Started with EDA Tools for EM Simulation and Analysis

By Gary Breed
Editorial Director

This tutorial includes a basic review of technologies, plus suggestions from several EM EDA vendors' Web sites, intended to help new EM EDA users.

Electromagnetic (EM) computer simulation has become one of the most powerful design tools for antennas, microwave circuits, and many high frequency active and passive components. EM is the “third leg” of the core techniques that define high frequency engineering. Like the other two—frequency-dependent effects and transmission line behavior—EM has a unique knowledge requirement, both at the theoretical level and in the implementation of computational tools.

Summary of EM EDA Techniques

There are two basic methods of implementing EM EDA tools—*planar* and three-dimensional (*3D*).

Planar EM tools take advantage of the layered nature of many high frequency circuits, such as microstrip, stripline or patch antennas on p.c. boards, hybrid circuits on ceramic substrates, and integrated circuits using layered fabrication. As you might expect, the advantage of 2D is that it offers simplified computation compared to 3D. And in some cases, multiple 2D layers can closely approximate a 3D structure.

However, there are many problems that must be solved with 3D EM tools. Many antenna structures, cavities, circuits and components do not have 2D or layered construction and occupy a volume that can only be defined using all three *x*, *y* and *z* dimensions. With ever-increasing computing power available at low cost, the traditional slow computations of 3D EM tools have largely been over-

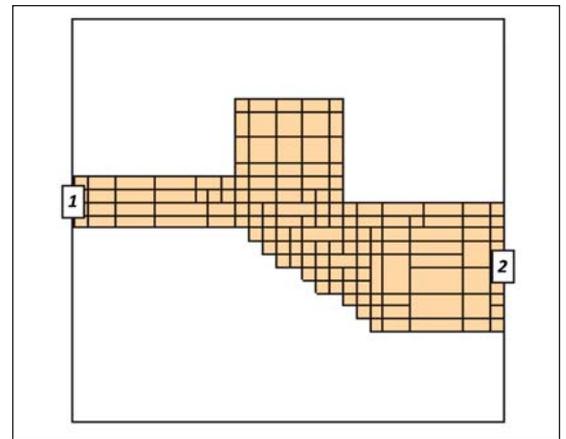


Figure 1 · EM Computations require division of the structure into discrete segments. Note that smaller segments are used at corners, and along diagonal edges (2).

come. Advances in mathematical algorithms have further reduced computation times for 3D EM.

In addition to the physical representation of the problem, there are three main mathematical approaches to the solution of EM problems—*Method of Moments* (MoM), *Finite Element Method* (FEM) and *Finite Difference Time Domain* (FDTD). Briefly, MoM is used primarily for planar and stacked planar structures; FEM is a frequency domain solver used for 3D structures that effectively handles multiple ports; and FDTD is a time domain solver that can handle large problems [1]. The beginning user should be aware that each method has advantages and disadvantages for certain structures or behaviors, which can be learned by reviewing vendor information and the technical literature.

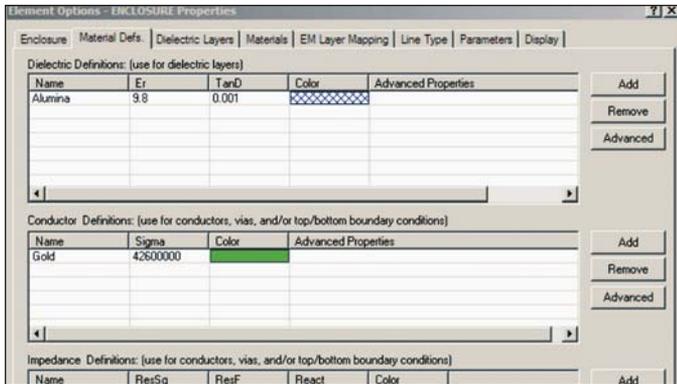


Figure 2 · An essential part of the problem definition is entering the material parameters.

Segmentation: The Key Issue

Maxwell's equations (as subsequently modified by other scientists and mathematicians) do not have closed-form solutions. Practical computation requires a series of point-by-point solutions, with each point being a physical location on the structure under analysis.

Figure 1 shows how a simple planar structure may be divided into rectangular segments. Each segment has results computed for interactions between it and all other segments, filling a large matrix. The results from all segments are then combined into a final solution.

Accuracy of the result depends on the granularity of the segments, while the speed of computation depends on the number of segments. Also, it is impractical for a user to manually divide a structure into segments, so EDA tools provide automated segmentation. Users must learn the best way to choose the number and density of the segments, including higher density of segments at critical locations such as bends, corners and other transition points where currents change quickly over distance.

Additional Parameters

The conductivity of the material (e.g., copper p.c. board or aluminum IC metallization) and dielectric constants of the substrate and surrounding media must be specified, since they are all part of the total structure. Figure 2 shows the material parameter entry screen of AWR's emsight tool [3].

Entering the physical dimensions of the structure is also a critical step in EM simulation. A new user's first explorations will probably use design examples provided by the vendor, but eventually, unique new designs must be analyzed. Simple structures may be drawn using internal utilities in the EM software, although this will become tedious for larger structures. Many designs will be available in other graphical formats, such as a common CAD tool DXF file. Vendors will have translation routines available, but users should be aware that the DXF format

supports more than simple physical dimensions and may have additional embedded data. All imported graphics files need careful attention.

Other parameters, such as enclosure or free space boundary conditions, may need to be specified by the user.

Various Notes from Vendor Data

Remcom's online "User Tips" [4] reminds users that high resolution analysis may not be needed in an early stage of a design, where a simple task like locating resonant frequencies is the primary objective. Less precise calculations may be sufficient and will be much faster.

Remcom's XF7 is a time domain engine, using an FFT for transformation to the frequency domain. Higher resolution for frequency domain plots (e.g., smoother S-parameter plots) can be obtained by increasing the FFT size. Be careful setting the value too high, because the FFT is a memory- and processor-intensive algorithm.

Agilent EEsof EDA offers a note on the recently popular "defected ground structures" (DGS) [5]. These intentionally designed defects on the ground plane create additional effective inductance and capacitance that results in microstrip lines with higher impedance, band rejections, and slowwave characteristics. However, since the design perturbations are incorporated into the ground plane structure, designers cannot assume ideal ground conditions. Also, there are no circuit models available for DGS in commercially available design tools, so the design and modeling of DGS are almost completely dependent on EM simulations.

Sonnet Software's Sonnet Lite is a free planar EM tool that is the first exposure to EM analysis for many engineers. Sonnet reminds users to be sure to go through the included tutorial. "This takes an hour or so and you will then be familiar with about 80% of Sonnet Lite's features and you can immediately start serious work. If you are going to be using Sonnet Lite a lot, we highly recommend reading the entire documentation package as you go along."

This advice is appropriate for all EM EDA tools. In addition to self-study, users will also benefit from online user forums and formal training provided by the vendors.

References

1. Andy Howard, "When Should You Apply 3D Planar EM Simulation?" Micro Apps, IMS2010, available at www.agilent.com/find/eesof.
2. "Getting Started," for Sonnet Suites, Release 12, Sonnet Software 2009, www.sonnetsoftware.com.
3. "MWO: Using the Electromagnetic Simulator," AWR Application Note 1, www.awrcorp.com.
4. User Tips, www.remcom.com.
5. EM Insights Series, "Episode #12: Simulation of Defected Ground Structure (DGS)," www.agilent.com/find/eesof.