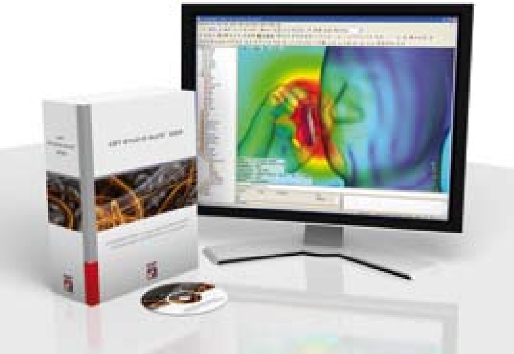
Microwave Journal



Efficient, Accurate, Reliable EM Simulation Tool

In the ongoing race for reduced design costs and faster time to market, simulation efficiency remains the most important factor in electromagnetic field analysis. Simulation efficiency can be determined by the time taken to reach the final design, which is strongly influenced by the level of workflow integration, the versatility in manipulating the model, the choice of solver type, the method's accuracy, the implementation's efficiency and, of course, the hardware speed. The new CST STUDIO SUITE™ 2009, incorporating the CST MICROWAVE STUDIO® (CST MWS) 3D electromagnetic field simulator for microwaves and RF, has been specifically designed to meet these requirements.

USABILITY

For this new version, the modeling interface has undergone a complete makeover. Besides changes that simplify user access to functionality, there are improvements in user interaction. Transformations such as translation, rotation and scaling can now be performed using mouse control. In addition, version 2009 features a special interactive alignment mode that allows geometrical objects in the model to be positioned easily with a few mouse clicks. The new alignment mode is automatically activated when copying objects between two projects by standard copy [Ctrl-c] and paste [Ctrl-v] operations, or when importing sub-projects into the main project.

Conformal modeling is often required, particularly for antenna applications. Version 2009 offers an interactive bending feature. ***Figure 1*** shows the 3D model of an antenna carrier. The antenna itself is modeled as a planar structure, which is then imported in a sep-

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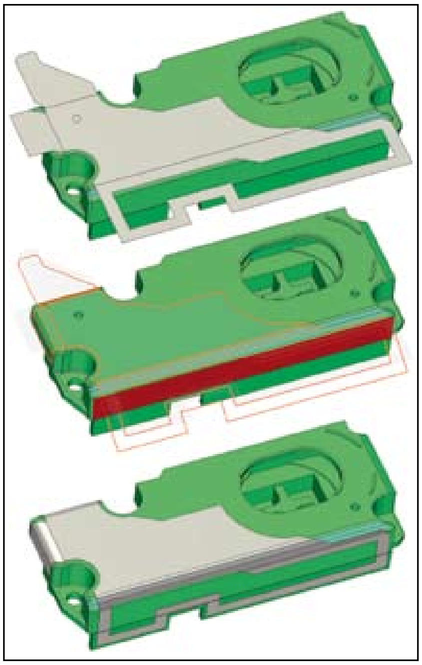
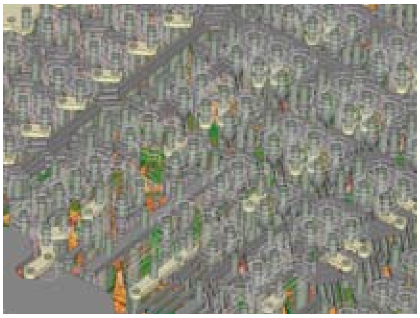
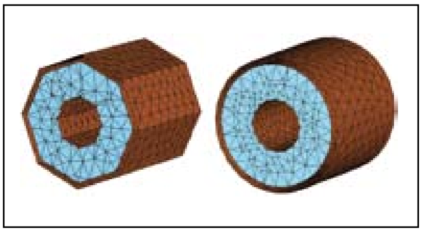
arate step. The two objects are aligned (see Figure 1; top), then the bending process is started by selecting individual faces (see Figure 1; middle, highlighted red) of the carrier onto which the antenna should be bent. Eventually the entire antenna is fitted perfectly to the carrier (see Figure 1; lower). This is actually very similar to the real procedure, where the antenna is printed onto a flexible foil and then attached to the carrier.



▲ *Fig. 1 Interactive bending of a fictitious antenna onto a carrier.*



▲ *Fig. 2 Complex EDA import for signal integrity analysis.*



▲ *Fig. 3 Coaxial waveguide after traditional (left) and true surface (right) mesh adaptation.*

Perhaps the most important among all the improvements to the modeling front-end is not visible at all; the entire user interface has been ported to 64-bit in order to serve the demand for dealing with increasingly complex models.

INTEROPERABILITY

Workflow integration has always been a key concern in CST's development. All import filters available in the CST STUDIO SUITE are characterized by their robustness and ability to deal with flaws in the imported models. Besides updating the CAD kernel and the existing import filters, the palette of available imports/exports is being continuously extended. Version 2009 now features Nastran, GDSII and Gerber exports.

Particular attention has been directed to the imports from EDA tools, e.g. from Cadence®, Mentor Graphics® and Zuken®, since the investigation of signal integrity is becoming an increasingly important application area for 3D EM simulation. These EDA interfaces can also deal with importing lumped circuit components. A completely new feature is the Mentor Graphics PADS® import.

SIMULATION PERFORMANCE

Computers are getting faster every year. But while CST has seen a performance increase for desktop workstations of about a factor 25 for a simple scalar textbook FDTD implementation in the last 10 years, the increase in average model complexity is actually greatly outweighing this. Factor increases of 1000 in numerical model size are not uncommon (see ***Figure 2***). For a mobile phone simulation, 10 years ago it was acceptable to replace the actual mobile phone by a metallic block and focus on the antenna. Today the entire mobile phone, its antennas, PCB, cameras, etc., have to be simulated, while also considering the presence of the phone user's head, hand, perhaps even the entire body, and the environment it is in.

Improvements in both the algorithms and hardware concepts must be leveraged. The neglect of one of these aspects necessarily leads to decreased performance. On the algorithmic side, CST takes the complete technology approach. An Allen screw can be tightened much quicker with an Allen key than with any other kind of screwdriver. Similarly, users can choose the tool within CST MWS that best suits their application.

On the next level, technologies like the Perfect Boundary Approximation (PBA)®, the Thin Sheet Technology (TST)™ and the Multilevel Subgridding Scheme (MSS)™ can improve performance dramatically. Improvements in implementation have also led to significant performance gains in the frequency domain solver.

Improvements on the hardware side are taking place at various levels. Together with Intel®, performance on desktop workstations has been further improved. In collaboration with Acceleware, GPU-based hardware acceleration has been made available to CST MWS users. Currently one-, two- and four-card solutions are available. Compared to high-end desktop workstations, speed-ups of up to a factor 19 have been achieved for typical applications. The upcoming realizations of GPU-based hardware acceleration using Nvidias Compute Unified Device Architecture (CUDA) programming language promise further performance improvements.

MPI FOR CST MWS

Hardware acceleration solutions for CST MWS are currently limited to a maximum of 96 million mesh nodes. Very complex structures such as multilayered PCB boards or electrically large models can easily exceed this limit. They will benefit most from the company's latest development: A message passing interface (MPI)-based parallelization of the CST MWS transient solver. By decomposing the calculation domain into several parts and distributing these parts to computers in a cluster, the simulation of models with several hundreds of millions of mesh nodes becomes feasible. At the same time the simulation is sped up by using several CPUs and memory interfaces in each individual computer.

TRUE SURFACE MESH ADAPTATION

As an additional algorithmic advance, the mesh adaptation of CST MWS's tetrahedral frequency domain solver has been entirely revised. Traditionally, adaptive refinement of HF frequency domain solvers based on a tetrahedral grid does not improve on the initial facetted representation of the structure. The originally created tetrahedra are simply divided further where necessary. The mesh adaptation will converge, not to the results of the actual structure (e.g. S-parameters), but to those of the initial segmented model (see ***Figure 3***; left). CST's mesh adaptation approach is different. After every adaptation step the proposed refinement is projected back onto the original model. This leads to an improved geometry approximation and to a convergence to the real results of this structure (see Figure 3; right).

INTEGRAL EQUATION SOLVER

Introduced for the solution of electrically large structures in CST MWS version 2008, the integral equation solver, based on the multilevel fast multipole method (MLFMM), is catching up with the rest of the company's solvers with respect to available features. The performance improvements over the previous version are dramatic. Besides MLFMM, an iterative MoM solver is available for solving structures that are electrically not very large, i.e. in the range of about 5 to 20 wavelengths. The memory efficiency is also good (N log(N) compared to N^3 for normal MoM).

TRUE TRANSIENT EM/CIRCUIT CO-SIMULATION

Particularly beneficial for engineers working in signal integrity, CST STUDIO SUITE 2009 additionally features true transient EM/circuit co-simulation. In standard EM/circuit co-simulation, the circuitry and 3D structures are solved separately, and S-parameter models represent the 3D EM structure in a circuit simulator [e.g. CST DESIGN STUDIO™ (CST DS)], which then solves the entire set-up.

CST MWS models, for example, can also be used within Agilent ADS or AWR Microwave Office. Although this is not co-simulation in the sense that 3D EM fields and circuit components influence each other, it is very useful to analyze and optimize a system in a way that also accounts for full 3D effects.

The new scheme available in version 2009 follows a different path, although the principal set-up looks very similar. A full 3D structure is represented by a block in a schematic, and circuit components are attached to its ports. The transient 3D EM/circuit co-simulation exchanges currents and voltages continuously at the ports between the CST MWS EM simulation and the circuit simulation in CST DS, while the signal propagates through the model (see ***Figure 4***).

There are two major advantages of transient compared to standard EM/circuit co-simulation:

- The full S-matrix of the 3D EM structure is no longer required since the circuit elements are directly interacting with the electromagnetic field simulation. This is advantageous particularly for PCBs with many ports and many lumped elements because the full S-matrix derivation of such a device can be extremely time consuming and is not always necessary for the investigation of critical parts.
- Transient EM/circuit co-simulation can also simulate the transient electromagnetic fields that result from the interaction with non-linear elements such as diodes. The broadband nature of the transient simulation means that many harmonics are automatically taken into account (see Figure 4).

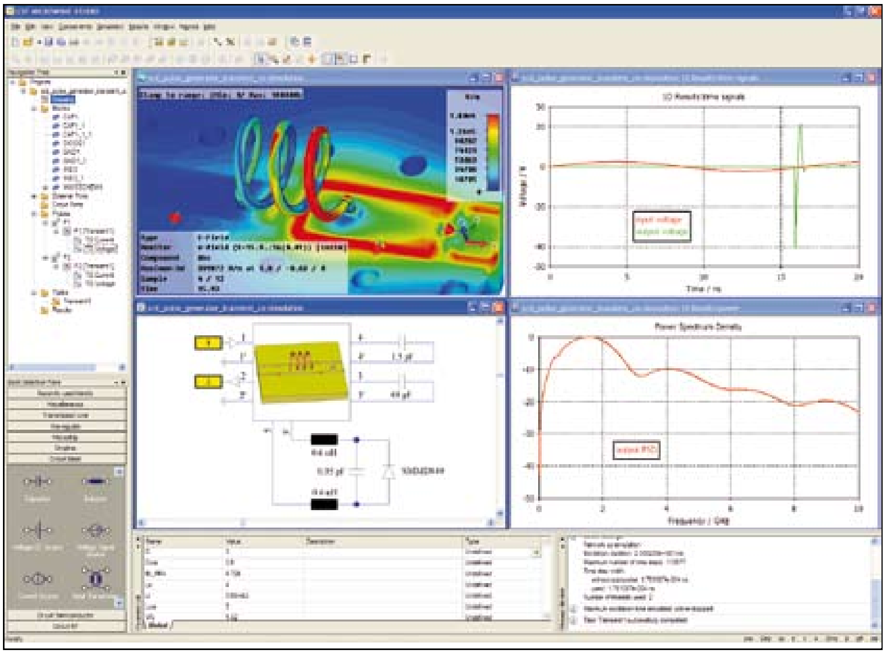


Fig. 4 Transient EM/circuit co-simulation.

TRANSIENT THERMAL SIMULATION

The thermal analysis of electromagnetic losses is a natural augmentation of EM simulation tools. In previous versions, a stationary heat equation solver was available. In version 2009 its capabilities are extended to simulate the transient behavior of the heating process. For the benefit of modeling biological tissues, both thermal solvers have been extended to include the bio-heat equation.

NEW PRODUCTS

Version 2009 features two entirely new products: CST PCB STUDIO™ (CST PCBS) and CST CABLE STUDIO™ (CST CS). Both are based on SimLab technology and are fully integrated in the CST DESIGN ENVIRONMENT™. CST CS simulates fields on cable harnesses while CST PCBS focuses on PCBs. Signal integrity and conducted emissions can be directly evaluated in these tools, and calculated surface currents can be used to conduct a radiation analysis in CST MWS.

CONCLUSION

Version 2009 efficiently leverages new technologies to reduce simulation times and increase interoperability offering improved usability and simulation capabilities, as well as two new products. As a result users benefit from an accurate and reliable tool that speeds up their design process and smoothly integrates into existing design flows.

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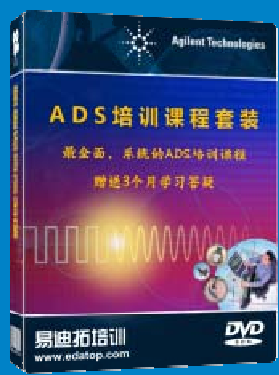

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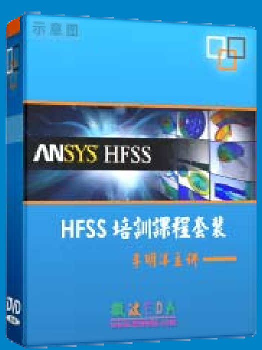

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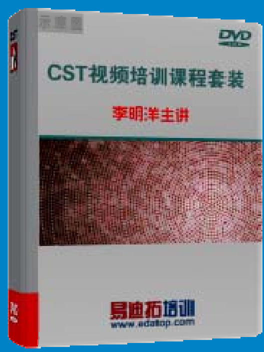

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