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3-D EM Simulator is Integrated with ADS to Lower the Cost of Design

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With EMPro 2009, high performance time domain (FDTD) and frequency domain (FEM) EM analysis is integrated with all the other Advanced Design System (ADS) capabilities

Full 3-D electromagnetic (EM) simulation used to be an analysis tool for EM experts tackling the toughest antenna or passive component design problems. Today, however, consumer wireless technology trends are pushing high-frequency and high-speed circuits, packages, modules, and antennas into ever smaller form factors. The resultant 3-D EM proximity effects now must also be considered by circuit and module designers. Discovering and fixing these proximity issues during hardware testing often occurs very late in the design process, which is too expensive.

EMPro 2009, the new EM platform from Agilent EEsof EDA, brings powerful 3-D EM simulators within an efficient and intuitive 3-D design environment that is easily accessed by circuit and module designers in the industry-leading Advanced Design System (ADS) design flow. The dedicated 3-D design environment enables the intuitive creation of 3-D parameterized components such as metal shields, packages, laminates, dielectric bricks and interconnects for insertion into the ADS 2-D circuit layout environment. The resulting combined circuit-3-D EM simulation will then reveal any unexpected interactions among the components. Unlike a design process that uses standalone 3-D EM tools, the parameterized 3-D EM components in ADS enable quick and convenient adjustments to the component geometries, providing insight into the EM effects on the design without leaving the design flow.

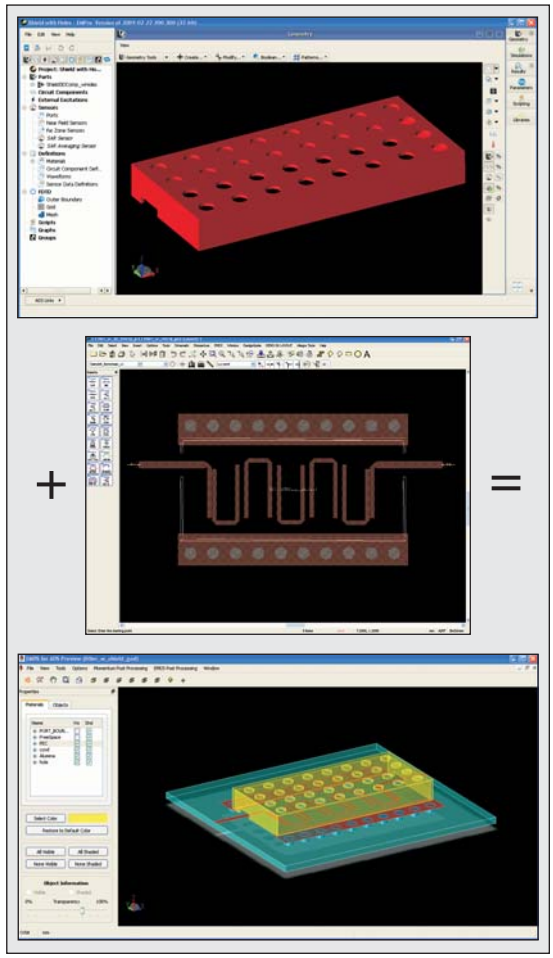

Figure 1 · EMPro 2009 creates a 3-D parameterized component (metal shield) that integrates with the ADS circuit (a filter) for fast, efficient simulation and optimization.

In the past, using point tools, designers needed to leave the design flow to perform multiple 3-D drawings, design setups, re-sim-

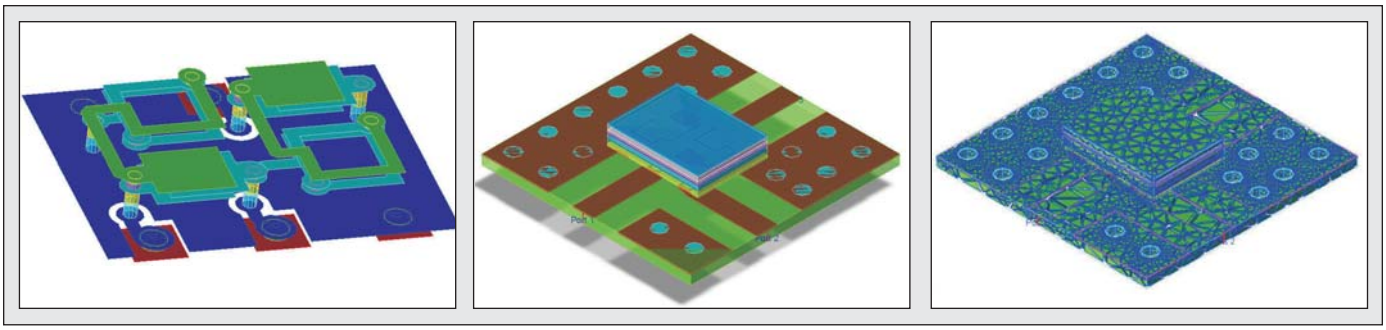

Figure 2 · An example LTCC Balun, showing the module, the LTCC Balun mounted on test board, and the Balun and test board meshed for full FEM 3-DEM simulation.

ulations, and error-prone manual imports. EMPro's 3-D EM integration into the circuit or module design flow can save designers hours per simulation. This can dramatically lower the overall cost of design.

The 3-D EM design environment in EMPro 2009 is designed to provide the fastest route from 3-D drawing to accurate simulated results. The key capabilities include:

- Two powerful 3-D EM simulators in one platform: Finite Element Method (FEM) and Finite Difference Time Domain (FDTD) simulators cover the broadest range of applications, from electrically small components to electrically large antennas. They also provide convenient cross-validation from both time- and frequency-domain 3-D EM analyses for the same structure, helping designers to gain insight and to have greater confidence in their designs without needing to laboriously re-enter designs and simulation setups in separate tools.
- Efficient import, parameterization, and setup of complex 3-D CAD designs for 3-D EM simulation. For example, multiple simulations over a family of geometries for a complete cell phone can be done in one batch, without long repetitive manual setups for each simulation.
- "Set-it-and-forget-it" material assignment. Drag and drop assignments onto the imported 3-D object from an extensive material database to set up the simulation. Subsequent CAD imports inherit the assigned material properties for even faster simulation startup.
- Interactive 3-D editing with intuitive context-sensitive on-screen cues remove the constant need to look away from the drawing to select from cluttered menu picks and dialog boxes, allowing designers to complete the 3-D drawing quickly and efficiently.
- Direct parameterization by simply typing over any numerical dimension with an equation variable, the value of which can further depend on multiple other variables. This enables linked geometry sweeps or drawing mathematically defined surfaces for antennas to obtain the optimal performing geometry.
- Adaptive meshing follows the shape of the critical components to always deliver the best accuracy and convergence in a 3-D EM simulation. It remains active during parameterized sweeps to ensure the most accurate simulation possible.
- Dynamic real-time plots during simulation allows designers to begin see EM effects as the simulation runs and without waiting for it to complete. Designers can interrupt the simulation to adjust the geometry and the built-in intelligent simulation setup will restart with minimal user input.
- Intuitive setup of EM field sensor locations and immediate viewing of results for antenna far field, Specific Absorption Rate (SAR) and Hearing Aid Compatibility (HAC) through multi-threaded accelerated post processing, eliminating the long wait in traditional 3-D EM simulators, where post processing can take as long as the simulation itself.

EMPro Application Examples

The following examples of typical RF modules, interconnects, antenna designs, and packages demonstrate the value of EMPro's capabilities for achieving a faster, more accurate engineering design flow in the ADS environment.

LTCC (Low Temperature Co-fired Ceramic) or Laminate RF Modules

RF modules typically are constructed from multilayer ceramic or laminate dielectric material with embedded RF passive components between the layers. Such dielectric brick structures cannot be accurately solved by planar 3-D EM simulators, which assume infinite dielectric layers and do not account for edge proximity fringing. The embedded RF components are drawn by RF circuit layout macros which would be very time consuming to reproduce in a standalone 3-D EM tool. Hence FEM full 3-D EM simulation integrated within the circuit design flow is the ideal solution for these applications.

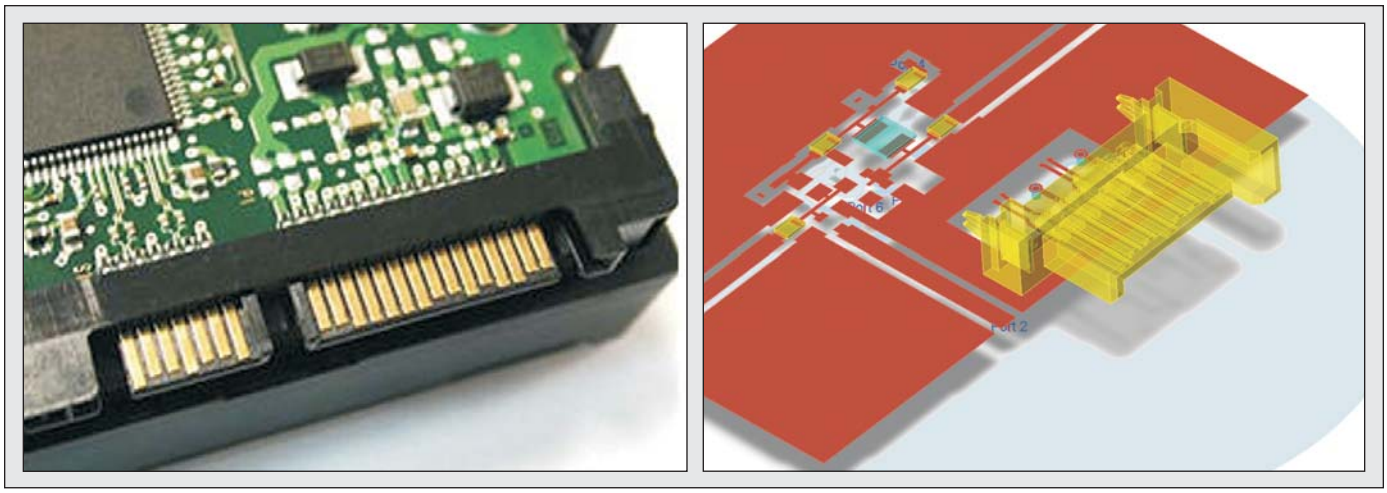

Figure 3 · SATA connector modeling in EmPro.

High-Speed/High-Frequency Connectors

High-speed and high-frequency interconnects are now an integral part of the digital interface designs for PCs, peripherals, and portable computing devices such as netbooks and smart phones. The following example (Figure 3) shows the Serial Advanced Technology Attachment (SATA) Connector in disk drives that potentially has to support 6 Gbits/s data throughput. The *S*-parameter models of the SATA connector family are developed in EMPro and can be cross-verified with the included FEM and FDTD simulators to give designers double confidence in 3-D EM simulation accuracy. The models are contained in an ADS design kit that can be distributed and installed into ADS

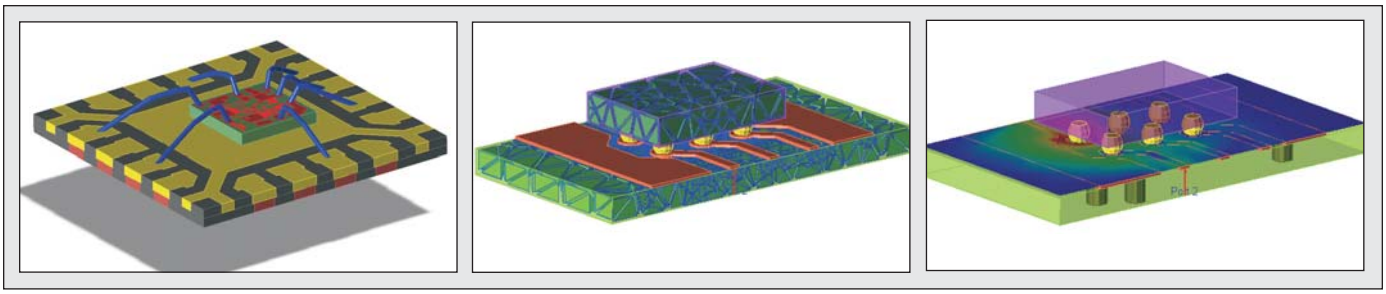

Figure 5 · Analysis of the 3-D EM effects of bond wires, flip-chip solder balls/bumps and packages can be included in the MMIC/RFIC and System-In-Package (SIP) design flow.

as a connector library for use in signal integrity analysis and design of high-speed serial channels.

The next example shows a simulation of the antenna performance in wireless consumer products such as 4G smart phones, netbooks, and routers under realistic operating surroundings that include the product housing, battery pack, PCB boards, and proximity orientation relative to the human hand and head. It is quite remarkable that such a simulation is even possible, but with GPU accelerated FDTD simulation and multi-threaded post processing, results like those shown in Figure 4 can be obtained in approximately one hour.

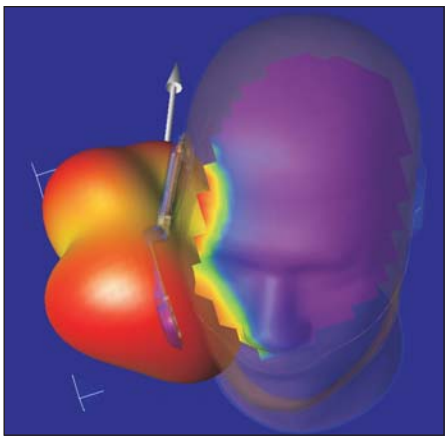

Figure 4 · EMPro allows designers to simulate antenna performance under real world conditions in a cell phone enclosure including human head and hand proximity to determine SAR, HAC (hearing aid compatibility), MIMO (multiple input, multiple output) correlation and feed impedance.

With these fast computation times, it is an easy matter to examine multiple orientations of the antenna, representing different human user handling positions, providing the necessary data for the design of adaptive antenna matching circuits in ADS. The temperature rise in the human head due to cell phone antenna radiation can also be checked for compliance against industry safety Specific Absorption Rate (SAR) standards, so that expensive rework on the actual phone during hardware testing can be avoided.

IC Interconnects to Package, System-In-Package with Wire Bonds, or Flip-Chip Solder Ball

The design of an RFIC, MMIC, or SIP is not complete until the effects of packaging and the interconnects between them such as wire bonds, solder balls, or solder bumps are considered. Traditionally, designers had to draw and analyze them in a separate, 3-D EM tool and then laboriously import the results back to the IC or SIP circuit design environment for a combined analysis. Now, you can efficiently create these 3-D components in EMPro to be used with 2D circuit layouts in ADS in the co-design of IC, package, laminate, and module with circuit and 3-D EM simulation in a streamlined design flow.

Summary

Unlike standalone FEM or FDTD 3-D EM tools, EMPro 2009 includes both FEM and FDTD simulators under the industry's most modern and efficient 3-D EM design environment to cover the widest range of applications. It allows for cross-verification of time- and frequency-domain 3-D EM results to double the designer's confidence in the simulation.

Its integration with ADS, the leading high-frequency circuit design platform, provides a combined 3-D EM and circuit design flow in a single high performance design system, at substantially lower cost than that of owning and maintaining a collection of standalone tools.

Author Information

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