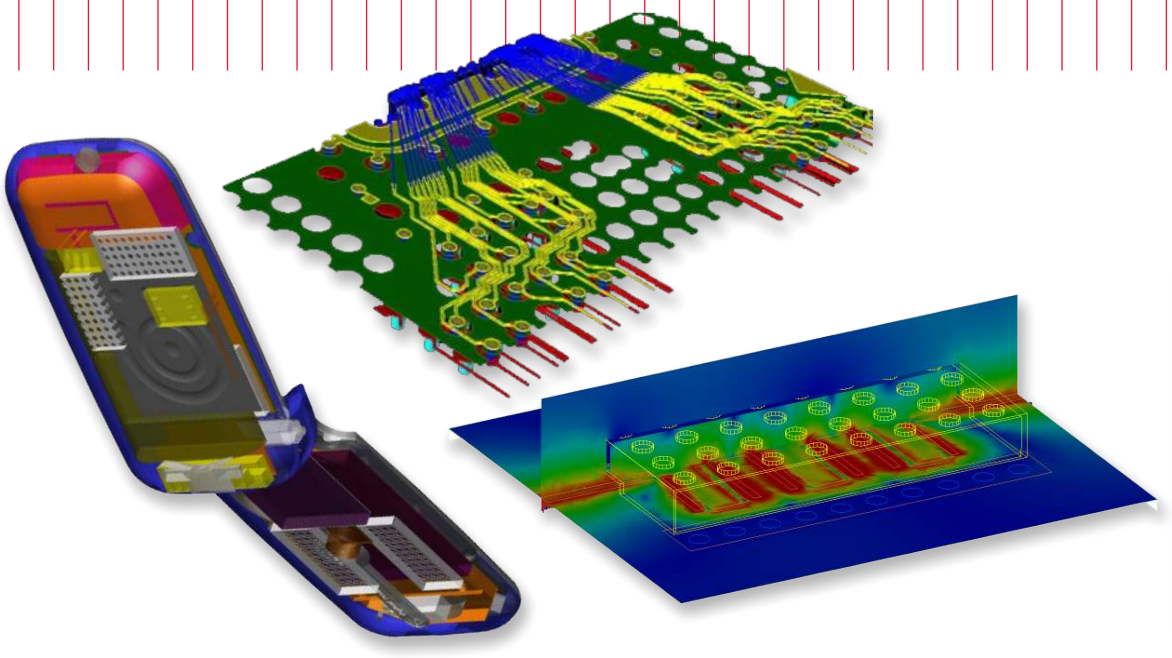
# Keysight EEsof EDA

# EMPro

## 3D Electromagnetic Modeling and Simulation Environment Integrated with your ADS Design Flow

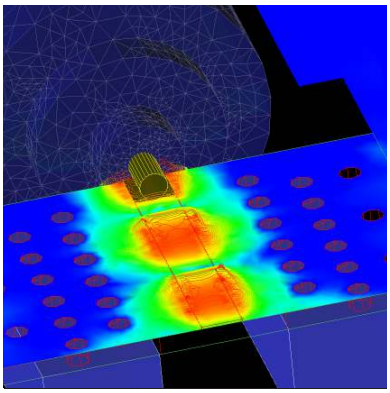
Application Note

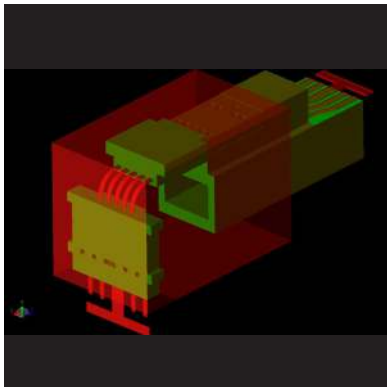


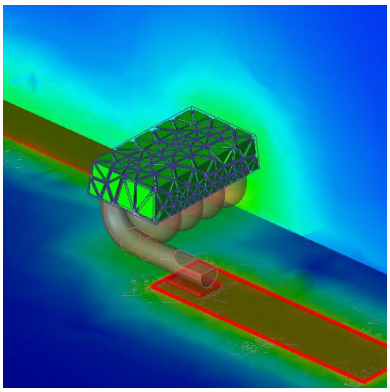
KEYSIGHT TECHNOLOGIES

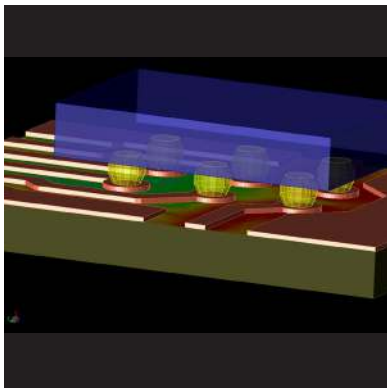
# Introduction

Electromagnetic Professional (EMPro) is a 3D modeling and simulation environment for analyzing the 3D electromagnetic (EM) effects of high-speed and RF/microwave components. EMPro features a modern design, simulation and analysis environment, high capacity time- and frequency-domain simulation technologies and integration with ADS, the industry's leading RF/microwave and high-speed design environment.









## EMPro delivers the following key capabilities:

### Modern, efficient 3D solid modeling environment

EMPro provides the flexibility of drawing arbitrary 3D structures and the convenience of importing existing CAD files. You can create 3D shapes, add material properties, set up simulations, and view results—all within the EMPro environment.

### Time- and frequency-domain simulation technology

3D structures can be analyzed in EMPro using the same FEM simulator available in ADS. FEM is a frequency-domain technology widely used for RF/microwave applications. For electrically large problems, such as antennas and some signal integrity analyses, the finite difference time domain (FDTD) simulator can be used.

### Integration with ADS

Parameterized 3D components can be created in EMPro and placed in a layout design in ADS. The 3D FEM simulator in ADS can then be used to simulate the combination of the 2D layout and the 3D EM component.

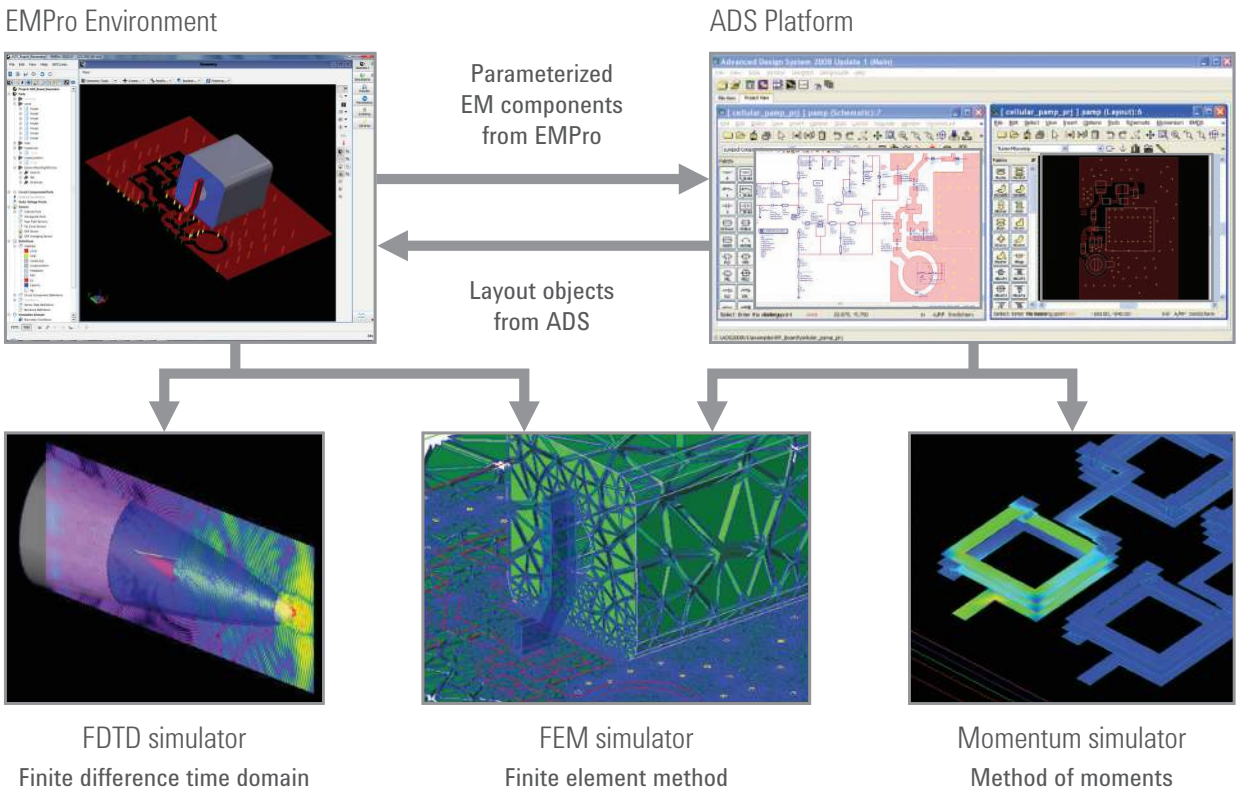
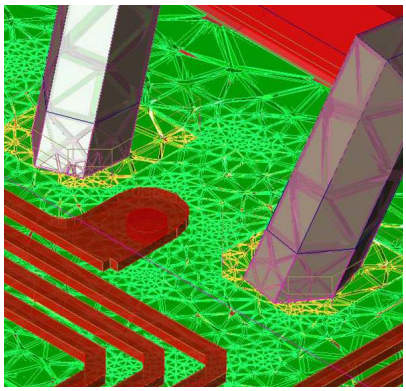



Figure 1. Keysight provides multiple EM simulation technologies integrated with the ADS design flow.

# EMPro Simulation Capabilities

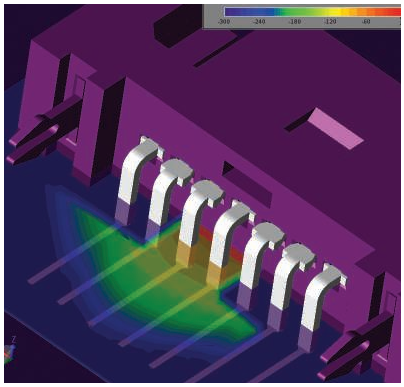
There are several different technical approaches to EM simulation, each with their own advantages in certain application areas. The most established 3D EM simulation technologies are FEM and FDTD. Both of these technologies are available in EMPro.



## Finite element method

FEM is a frequency-domain technique that can handle arbitrary shaped structures such as bondwires, conical shape vias and solder balls/bumps where z-dimensional changes appear in the structure. FEM solvers can also simulate dielectric bricks or finite-size substrates.

FEM is based on volumetric meshing where the full problem space is divided into thousands of smaller regions and represents the field in each sub-region (element) with a local function. The geometric model is automatically divided into a large number of tetrahedra, where a single tetrahedron is formed by four equilateral triangles. This collection of tetrahedra is referred to as the finite element mesh. The Keysight Technologies, Inc. FEM simulator includes both direct and iterative solvers, and both linear and quadratic basis functions, to solve a broad range of problems. The same FEM simulator is available in both EMPro and ADS. EMPro supports remote simulation and distributed frequency sweeps for FEM.



## Finite difference time domain

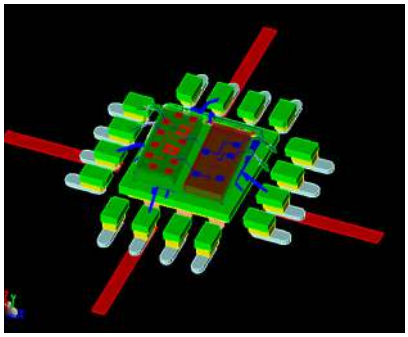
As with FEM, the FDTD method is based on volumetric sampling of the electric and magnetic fields throughout the complete space. Whereas FEM meshes consist of tetrahedral cells, FDTD meshes are typically built from rectangular (Yee) cells. The FDTD method updates the field values while stepping through time, following the electromagnetic waves as they propagate through the structure. As a result, a single FDTD simulation can provide data over an ultra-wide frequency range.

Because of its simple, robust nature and its ability to incorporate a broad range of linear and nonlinear materials and devices, FDTD is used to study a wide range of applications, including: antenna design, microwave circuits, bio/EM effects, EMC/EMI problems, and photonics. FDTD is an inherently parallel method and therefore lends itself very well to the processing capabilities of the most recent advances in CPU (general-purpose processors) and GPU (graphics processors) hardware. EMPro also supports remote simulation and distributed port simulations for FDTD.

Table 1. Summary comparison of FEM versus FDTD

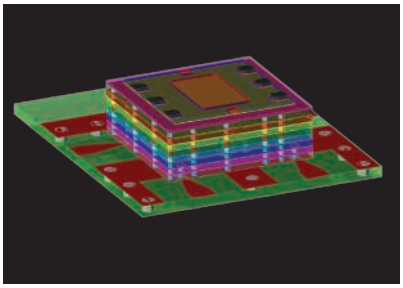
| FEM | FDTD |
|---|---|
| Frequency domain method | Time domain method |
| Tetrahedral mesh cells | Rectangular mesh cells |
| Good for high-Q structures | Good for broadband applications, physical transitions |
| Fast for multi-port simulations | Each port requires additional simulation |
| Based on solving matrix equations; best for electrically small problems | Based on iterative time stepping; less memory intensive for electrically large problems |
| Multi-threaded; problems can be divided and run in parallel on multi-core CPUs | Highly multi-threaded; problems can be divided and run in parallel on multi-core CPUs and on large GPU cards |

# Typical EMPro Applications



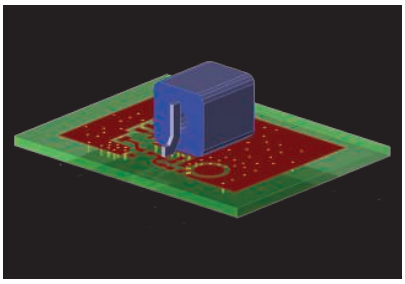
## IC packages

The performance of an RFIC, monolithic microwave integrated circuits (MMIC), high-speed IC, or system-in-package (SIP) is directly impacted by the effects of packaging, including wire bonds and solder balls/bumps. Traditionally, designers had to draw and analyze packages in a separate, 3D EM tool and then laboriously import the results back to the IC or SIP circuit-design environment for a combined analysis. With EMPro, you can efficiently create 3D package structures that can be combined with 2D circuit layouts in ADS. This allows co-design of the IC, package, laminate, and module with circuit simulation and 3D EM simulation in a streamlined design flow.



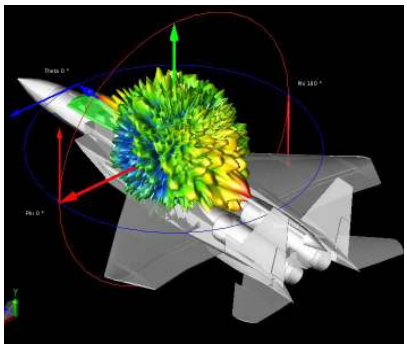
## Multi-layer RF modules

RF modules typically are constructed from multi-layer ceramic or laminate dielectric material with embedded RF passive components between the layers. Such dielectric brick structures cannot be accurately solved by planar 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 3D EM tool. Full 3D EM simulation integrated within the circuit design flow is the ideal solution for these applications.



## RF components

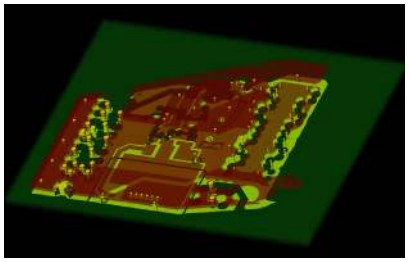
RF board designs include 3D components and connectors that need to be characterized to high frequencies. Components such as resonators are sensitive to interactions with the surrounding PC board traces and vias. Such 3D components can be created and simulated in EMPro and then combined with a board layout in ADS for complete 3D EM simulation.



## Aerospace/Defense

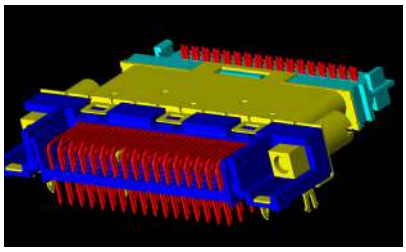
FDTD simulation has extremely high capacity and can handle large problems found in aerospace/defense applications.  For example, FDTD can be used to optimize antenna placement in aircraft and perform Radar Cross Section analysis.

# Typical EMPro Applications *(continued)*



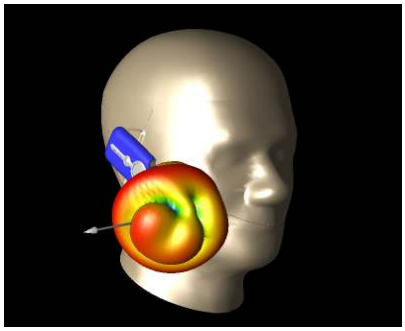
## PCB Design

With data rates increasing, PCB traces must now be analyzed as RF transmission lines. 3D EM technologies complement 3D planar simulators such as Keysight Momentum for high speed signal integrity analysis, EMI/EMC, and PCB interfaces to connectors and packages.



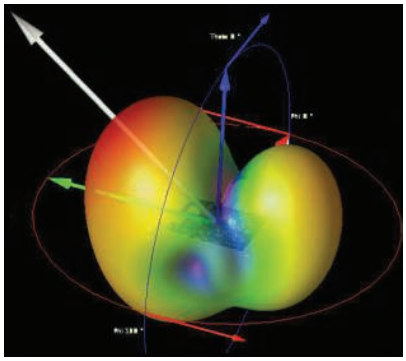
## High-speed connectors

High-speed connector types such as SATA and HDMI now support Gbits/s data throughput. High frequency S-parameter models of connectors can be generated in EMPro and cross-verified with both the FEM and FDTD simulators to give designers twice the confidence in 3D EM simulation accuracy. The models can then be included in an ADS design kit that can be distributed and installed into ADS as a connector library for use in signal-integrity analysis and design of high-speed serial channels.



## Handset antennas

A critical design task in the development of cellular and networking products is maximizing antenna performance while minimizing antenna size. EMPro can simulate the antenna in realistic surroundings, including the phone components, housing and even the human hand and head. Compliance testing can also be performed, such as specific absorption ratio (SAR) and hearing aid compatibility (HAC).



## EMI/EMC Analysis

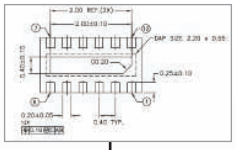
With more electronics being integrated into smaller packages, EMI problems are quickly becoming a leading cause of new product delays. EMPro allows engineers to simulate the radiated emissions of electronic circuits and components and then determine whether these emissions are within levels specified by common electromagnetic compatibility (EMC) standards, such as FCC Part 15, CISPR 22 and MIL-STD-461F and ensure that their designs are compliant.

# EMPro Environment Overview

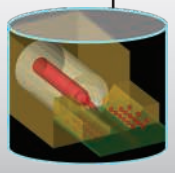
## Geometry modeling

- Arbitrary 3D structures can be created using the powerful EMPro drawing environment.
- Alternatively, structures can be imported from other CAD environments. Supported file formats include: ACIS, IGES, DXF, STEP, ProE, SolidWorks, ODB++ and others.
- Material properties are assigned to imported or drawn 3D objects using a simple drag-and-drop from an extensive material database onto the 3D objects. Once assigned, the material properties are memorized for subsequent CAD imports, enabling even faster simulation setup.

Draw from spec

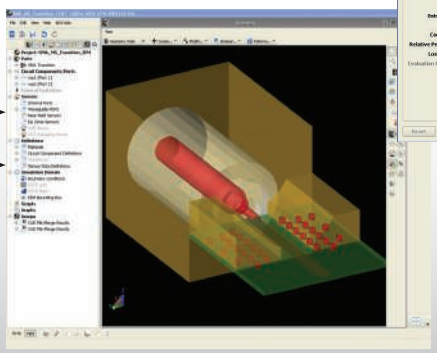


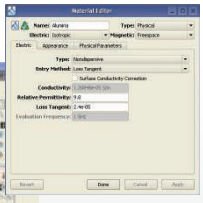
OR



Import CAD file

Define materials

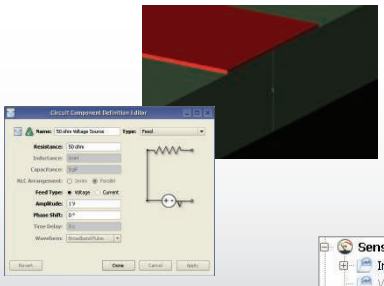




## Port/sensor setup

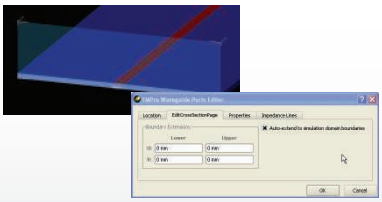
- General voltage and current sources can be placed on the object and the source impedance defined.
- Additionally, for FDTD simulations, external plane wave and Gaussian beam sources can be set up. Sensors are also set up to detect near-field and far-field voltages, currents and field quantities. Special SAR and HAC sensors can be added for compliance testing.
- For FEM simulations, waveguide ports can be set up.

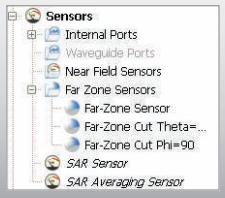
Define internal ports (FDTD, FEM)



OR

Define waveguide ports (FEM)



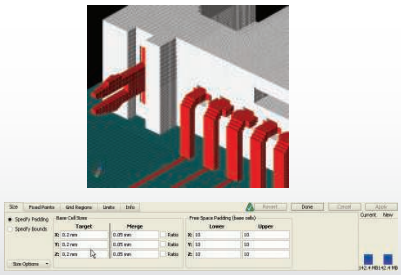



Define sensors

## Mesh setup

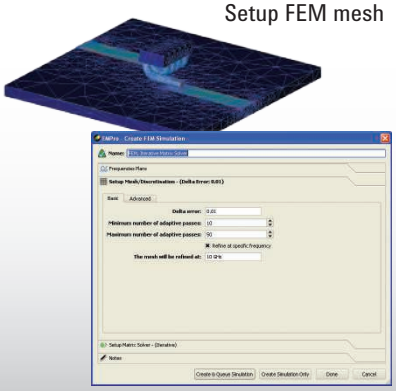
- For FDTD simulations, a rectangular mesh is generated based on the shapes of the objects. Initial mesh is automatically generated to optimize accuracy and simulation time. Fixed point meshing automatically aligns the mesh with object boundaries. Users can tune the mesh to make further trade-offs between accuracy and speed.
- In a similar fashion, a tetrahedral mesh is generated for FEM simulations. The mesh is optimized for speed/accuracy through a process of automatic adaptive refinement.

Setup FDTD grid/mesh



OR

Setup FEM mesh

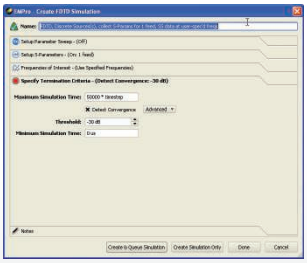


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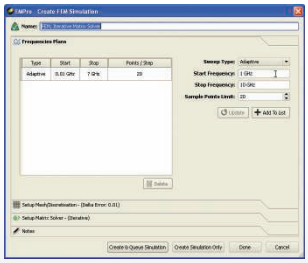
## Simulation setup

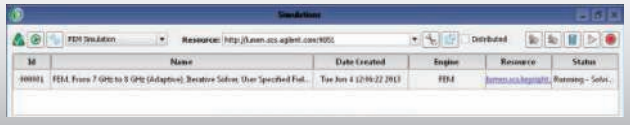
- Either FEM or FDTD simulation can be selected.
- For FEM, a frequency plan is created. Direct and iterative solvers are available and multi-threading capability on a multi-core CPU can be selected.
- For FDTD, multi-threading capability on a multi-core CPU or GPU card(s) can be selected.

FDTD



FEM

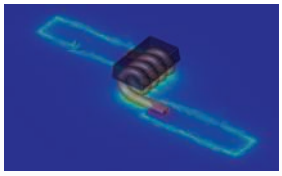


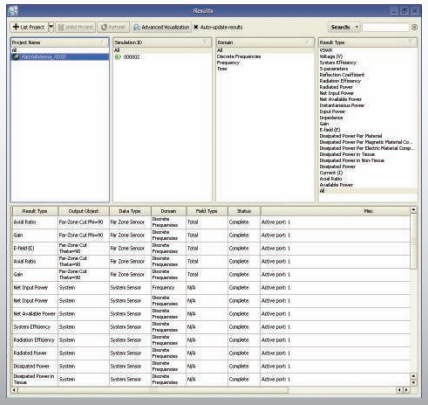


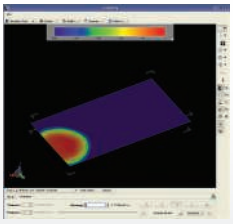
## Results post-processing and viewing

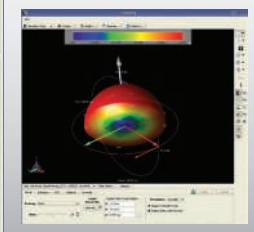
- S-parameter data can be plotted and compared with data from other projects.
- Advanced visualization of fields is available, including cut-plane views.
- Connectivity View can be used to find design errors, where small gaps between conductors might not be visible otherwise.
- Python scripting can be used for advanced post processing, and for automating simulations.

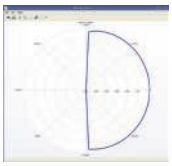
View results

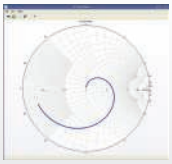


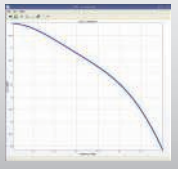






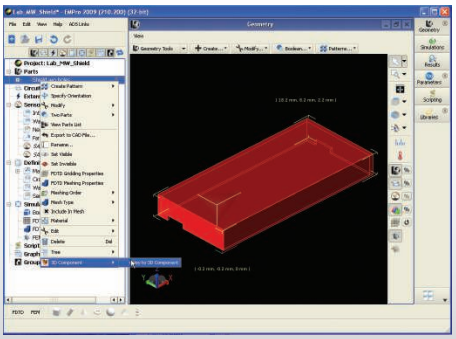






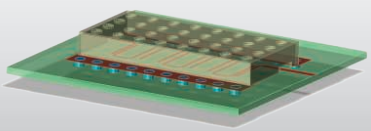
## Export 3D EM component to ADS library

- 3D structures such as packages, shields, connectors, and surface-mount components can be saved to an ADS library for use in both layouts and schematics, so that these structures can be simulated together with 2D layouts and circuit components.
- Components can be parameterized in EMPro to enable sweeps and optimization in ADS.
- The same FEM simulator is used in both EMPro and ADS to simulate the standalone component and the combination of the component and ADS layout.



Export to ADS Library





# EMPro Product Configuration

EMPro can be purchased as individual UI and simulator elements, or pre-configured bundles.

EMPro bundles are comprised of:

– W2401 EMPro core environment, which enables you to create and import arbitrary 3D structures, and

– Simulator elements, each of which provides specific capabilities.

| **EMPro bundles**<br>**EMPro elements** | **W2402B** | **W2403B** | **W2404B** |
|---|---|---|---|
| W2401 EMPro core element | √ | √ | √ |
| W2342 Keysight FEM simulator element | √ | - | √ |
| W2405 Keysight FDTD simulator element | - | √ | √ |
| W2406 Compliance Module | - | √ | √ |
| W2344 3d EM Distributed Computing 8-Pack | - | - | - |

W2344 3D EM Distributed Computing 8-Pack is compatible with both the W2342 Keysight FEM simulator element and the W2405 Keysight FDTD simulator element. It requires either one or both of the simulator elements to run.

W2406 Compliance Module is required to perform either SAR or HAC simulations.

W2342 Keysight FEM simulator element works with both EMPro and/or ADS.

W2401 includes CAD import license

W2342 includes CPU multi-threading license

W2405 includes CPU multi-threading license and GPU acceleration license

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| Brazil | 55 11 3351 7010 |
| Mexico | 001 800 254 2440 |
| United States | (800) 829 4444 |

**Asia Pacific**

| | |
|---|---|
| Australia | 1 800 629 485 |
| China | 800 810 0189 |
| Hong Kong | 800 938 693 |
| India | 1 800 112 929 |
| Japan | 0120 (421) 345 |
| Korea | 080 769 0800 |
| Malaysia | 1 800 888 848 |
| Singapore | 1 800 375 8100 |
| Taiwan | 0800 047 866 |
| Other AP Countries | (65) 6375 8100 |

**Europe & Middle East**

| | |
|---|---|
| Austria | 0800 001122 |
| Belgium | 0800 58580 |
| Finland | 0800 523252 |
| France | 0805 980333 |
| Germany | 0800 6270999 |
| Ireland | 1800 832700 |
| Israel | 1 809 343051 |
| Italy | 800 599100 |
| Luxembourg | +32 800 58580 |
| Netherlands | 0800 0233200 |
| Russia | 8800 5009286 |
| Spain | 0800 000154 |
| Sweden | 0200 882255 |
| Switzerland | 0800 805353<br>Opt. 1 (DE)<br>Opt. 2 (FR)<br>Opt. 3 (IT) |
| United Kingdom | 0800 0260637 |

For other unlisted countries:
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