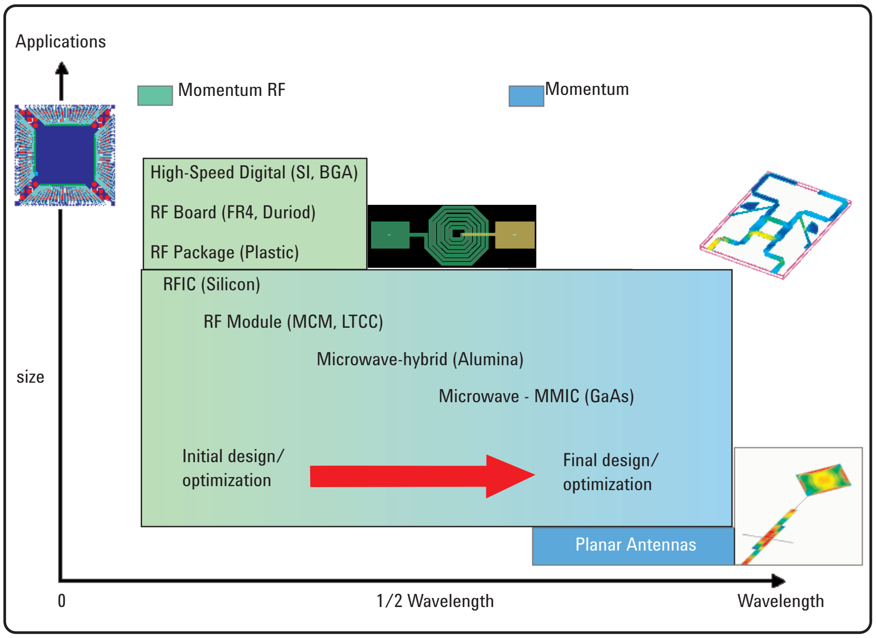
Agilent EEsof EDA E8921A/AN Momentum

Product Overview



Features at a Glance

Planar EM Solver

Momentum Microwave Mode
- Full wave solver
- Full dispersion and radiation

Momentum RF Mode
- Quasi-static solver
- Star-loop basis functions
- Arbitrary polygon mesh
- Stable and accurate from DC to half wavelength

Integration with ADS
- Easily incorporates EM designs into circuits for simulation
- Performs EM simulations directly from your Agilent ADS layout

Optimization and Visualization
- Design automation for planar simulation with Momentum Optimization
- Animate current flows and far-field antenna patterns with Momentum Visualization

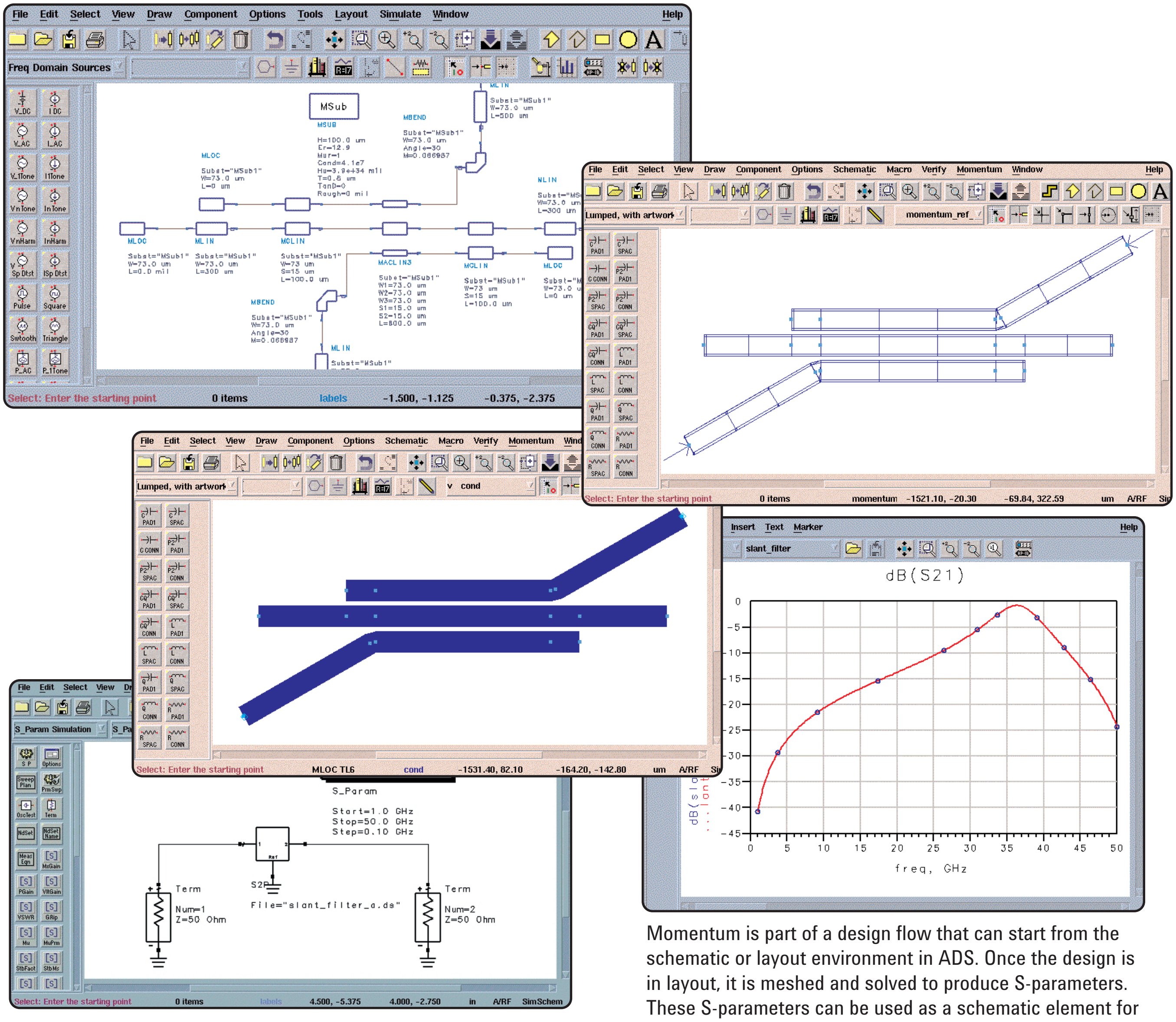
What is Momentum?

Momentum is a software tool from Agilent EESof EDA that helps predict the performance of high-frequency circuit boards, antennas, and ICs without extensive fabrication cost. It runs directly from the layout environment of the Agilent Advanced Design System.

It's important to use the right tool for the right job. Momentum now provides two solvers each specialized for different design tasks. The Microwave mode of Momentum (Momentum Microwave) provides an accurate approach for solving geometries that are large in comparison to the wavelength of the highest simulation frequency. For structures under a half wavelength, utilizing the RF mode of Momentum (Momentum RF) allows you to ignore effects such as space and substrate radiation.

Based on Method of Moments analysis, Momentum computes S-parameters of general planar circuits, including microstrip, stripline, slotline, coplanar waveguide, and other topologies. Vias and air bridges connect topologies between layers, allowing users to simulate multilayer RF/microwave printed circuit boards, hybrids, multichip modules, and integrated circuits.

Output chart formats include Cartesian and Smith charts, and tabular listings. Momentum responds to the increasingly stringent demands of high-frequency communications design: fast time to market, low-cost/high volume production, and physically smaller and denser products. Because circuit boards are built for increasingly smaller devices, components are placed closer together on the board, which increases the possibility of coupling and parasitic effects.



Momentum is part of a design flow that can start from the schematic or layout environment in ADS. Once the design is in layout, it is meshed and solved to produce S-parameters. These S-parameters can be used as a schematic element for further simulations as part of another circuit.

Momentum simulates the shape, size, and position of passive distributed circuits, accounting for their proximity. It supplements other simulation tools to let RF and microwave designers significantly expand the valid range and accuracy of their passive circuit libraries, including parasitic models or entire circuits. Unlike conventional circuit simulators, Momentum provides S-parameter data where no models exist, or where model ranges are exceeded.

When Should I Use Momentum?

When No Model Exists

Use Momentum when a circuit model does not exist. For example, with this program you can analyze a microstrip Y-junction.

When There Are Mixed Strip-Slot-Via Structures

Momentum has a highly efficient strip and slot formulation that processes strip and slot currents in similar ways. In ground plane structures, Momentum meshes the slot and not the whole ground plane, resulting in fewer mesh elements and faster simulations.

When the Model Range is Exceeded

Circuit simulator models are based on analytic equations that have range-limited control parameters, such as width, length, height, or dielectric constant. Some models break down gradually; others have errors that are significant under certain combinations of parameters. Momentum lets you go beyond built-in range limits.

To Calculate Parasitic Coupling

Even when circuit models are physically far apart, unexpected coupling can take place. Momentum predicts parasitic coupling and radiation.

Microwave Mode

Integrated Configuration

A key advantage of Momentum over other planar electromagnetic simulators is its integration into the Agilent Advanced Design System environment. When used in combination with Agilent Advanced Design System, Momentum lets you quickly perform electromagnetic analyses and use a common interface for both electromagnetic and circuit analyses.

Open or Closed Environment

Momentum can be used to simulate open environments (such as patch antennas) and closed environments (such as box enclosures).

Sidewall Coupling

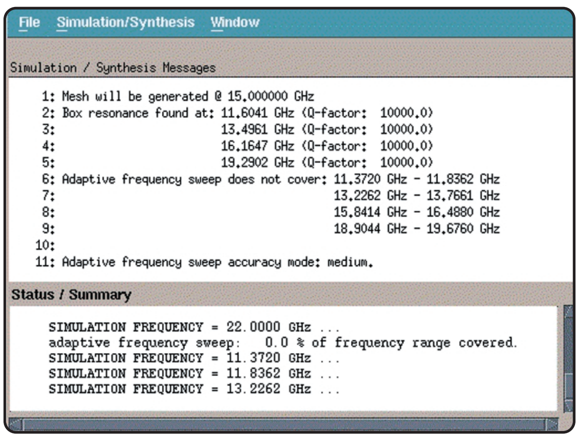
With Momentum, sidewalls can be included in the analysis to simulate the effects of placing a circuit near a package sidewall. Momentum calculates two or four sidewall structures as well as open structures. This lets the designer account for sidewall parasitic coupling, image currents, and box resonance. This differs from previous releases, where simulations were based on open, infinite sheets of dielectric.

Box Resonance Calculation

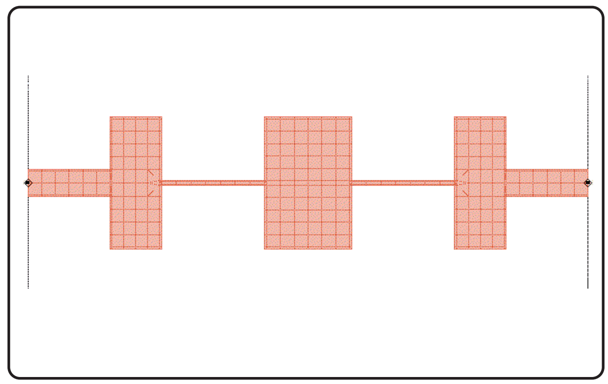
Circuits in an enclosed structure are affected by box resonances. Momentum calculates box resonance and determines if it occurs in the frequency range of interest. It then excludes those areas from the frequency sweep, since S-parameters can be discontinuous and can behave erratically in areas of resonance.

Arbitrary Meshing of Polygonal Shapes

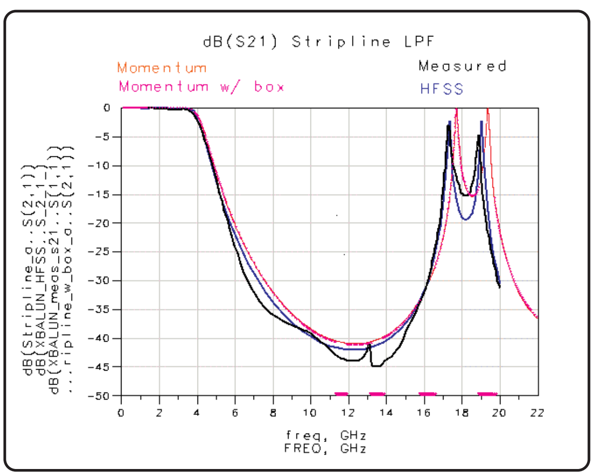
Momentum uses a combination of rectangular and triangular elements to mesh the geometry. There is no need to conform the geometries to a uniform background grid.



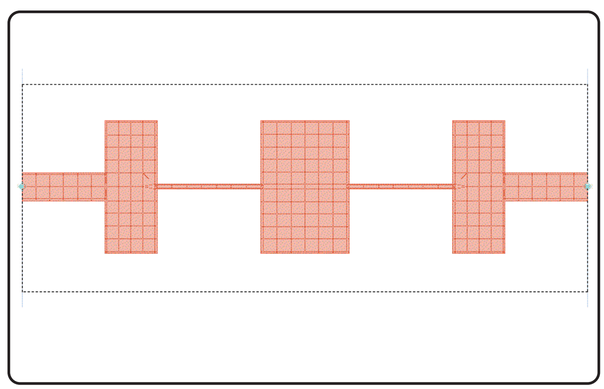
Box resonance calculations are reported in the message window.



Open environment.



Circuits can be simulated in either an open or closed environment. Box resonance frequencies are calculated and indicated on the plot as having a zero value frequency response.



Box enclosure.

Adaptive Frequency Sampling

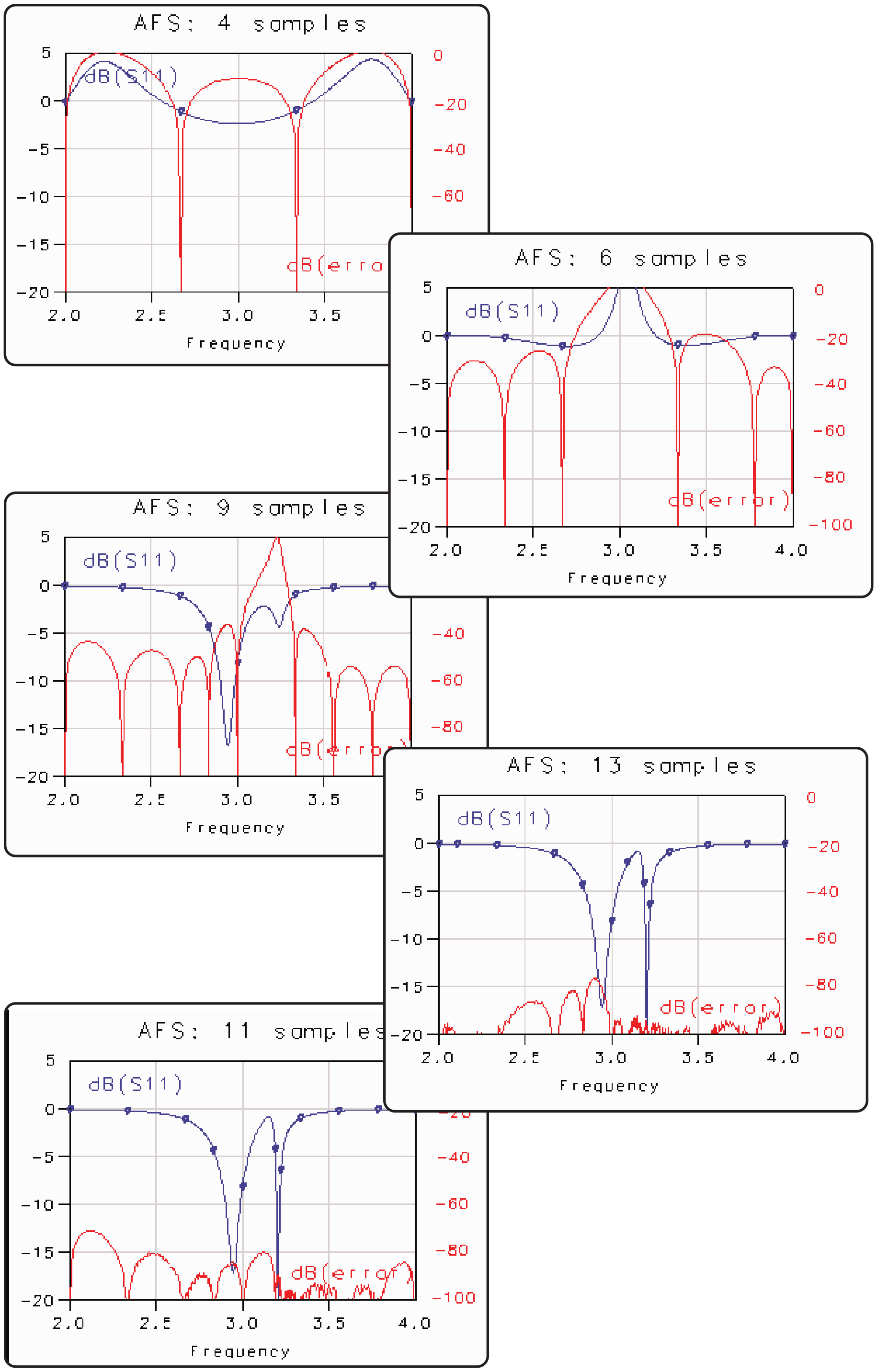
Adaptive frequency sampling selects frequency samples automatically and constructs a rational fitting function to represent the data over the entire frequency range. Important performance details are modeled by sampling the response more often when the S-parameters are changing rapidly. This results in a higher-resolution S-parameter response while minimizing overall simulation time.

DC and Low-Frequency Calculation

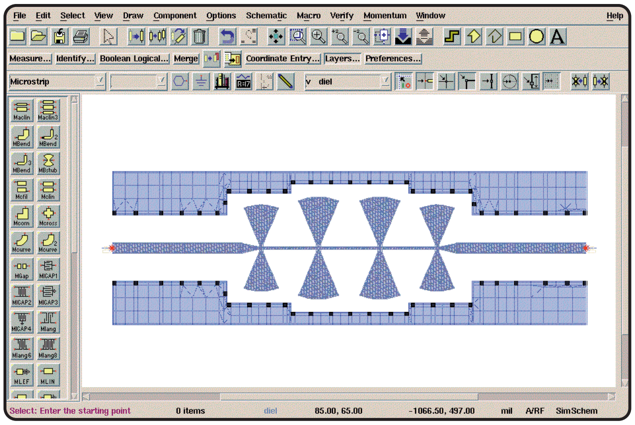
The S-parameter results of EM simulations are often used in circuit simulations. Momentum includes the ability to simulate and store DC and low-frequency S-parameters. This makes the data suitable for use as a circuit component where DC bias or low frequency AC to active devices is needed.

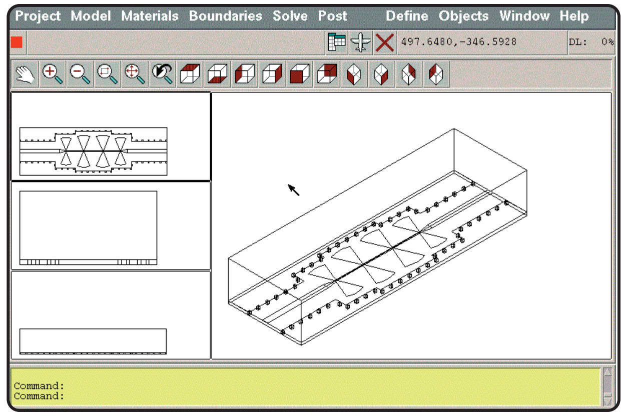
Automatic Mesh

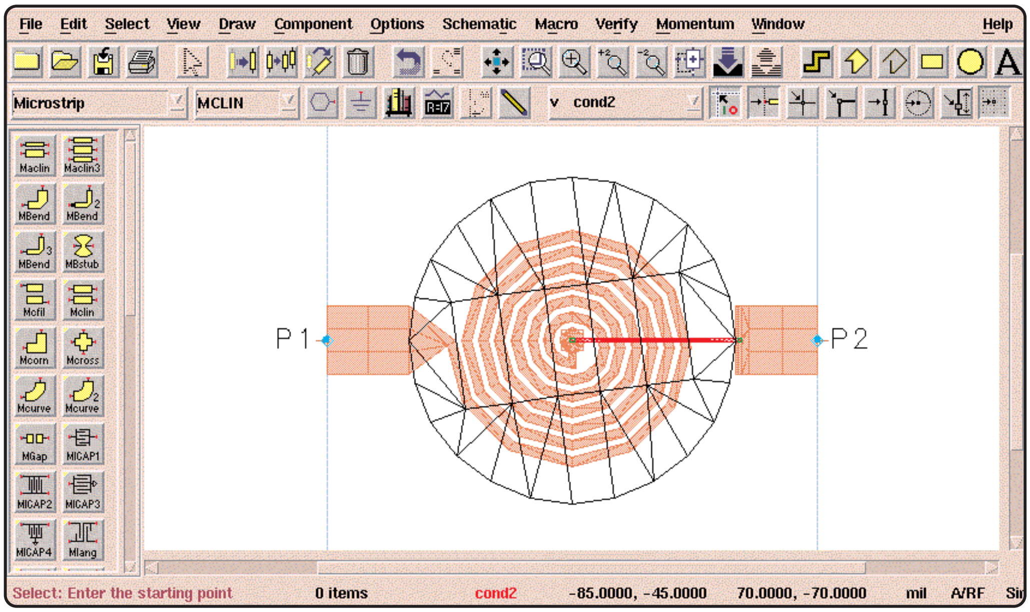
Planar electromagnetic simulators represent the current in a geometry by subdividing the pattern into cells or patches. With Momentum edge mesh, simulation time is minimized by placing a row of cells along the edges of the geometry. This accurately represents the current in structures such as microstrip transmission lines or spiral inductors, where the current is highly localized along the edge while minimizing simulation time.



The Adaptive Frequency Sampling process of selecting frequencies is illustrated here. The S-parameter response and the error function are shown.







Circuit Connections

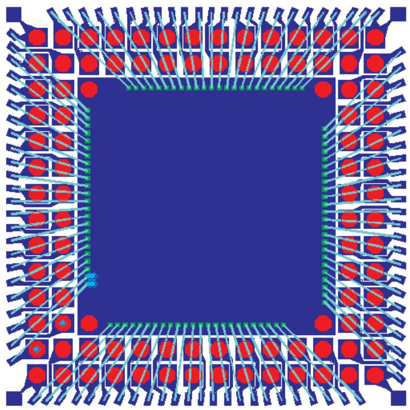
Internal ports can be put on any edge or surface of a geometry, including interior surfaces, rather than only on the perimeter of a pattern. This means that circuits of higher complexity can be simulated. Internal ports can be used like a wire bond for driving a circuit from some interior location of the geometry. These ports also provide access points for the schematic simulator to connect external components such as capacitors, inductors or even whole subcircuits to the Momentum simulation results. Electric and magnetic currents efficiently model metallic patterns (electric current) and slots in ground planes (magnetic currents).

Normalized and Generalized S-Parameters

Momentum normalizes the S-parameters with respect to 50 ohms. However, the built-in cross-section solver produces the characteristic impedance and propagation constant for the port transmission lines, allowing you to calculate generalized S-parameters and to shift the reference plane (de-embedding).

SPICE Model Generator

The Momentum SPICE Model Generator is now part of the linear simulator. It converts S-parameters from a Momentum result into a SPICE netlist or an RLCG netlist. This generates an equivalent circuit so that you can use your results in a SPICE simulation.



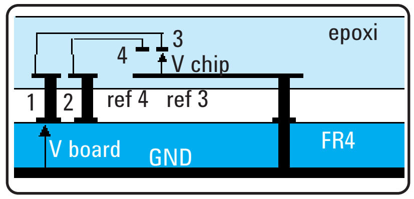
Momentum
Mesh: 20 cells/wavelength, 5 GHz

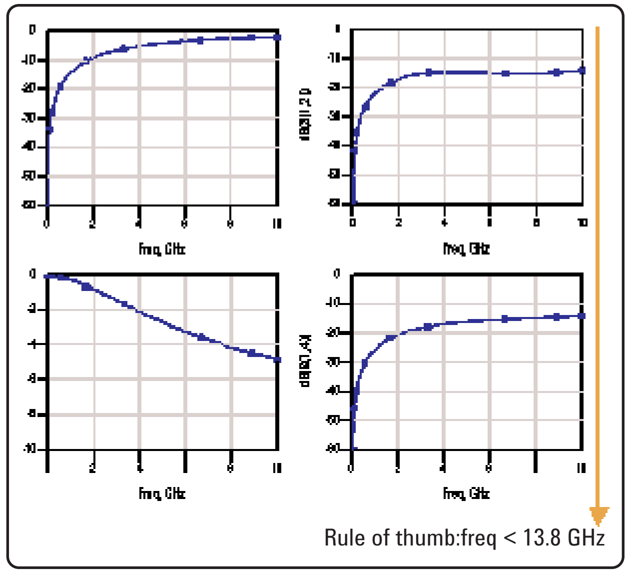
Matrix size: 8244
Process size: > 1 GB
*User time: > 2 days

Momentum RF
Mesh: 20 cells/wavelength, 5 GHz

Matrix size: 1354
Process size: 106.57 MB
*User time: 5h 17m 53s

*Pentium II 300 MHz





Simulation time is dramatically reduced. Momentum RF is valid up to a half wavelength, which, for this structure, is reported as 13.8 GHz.

Momentum RF

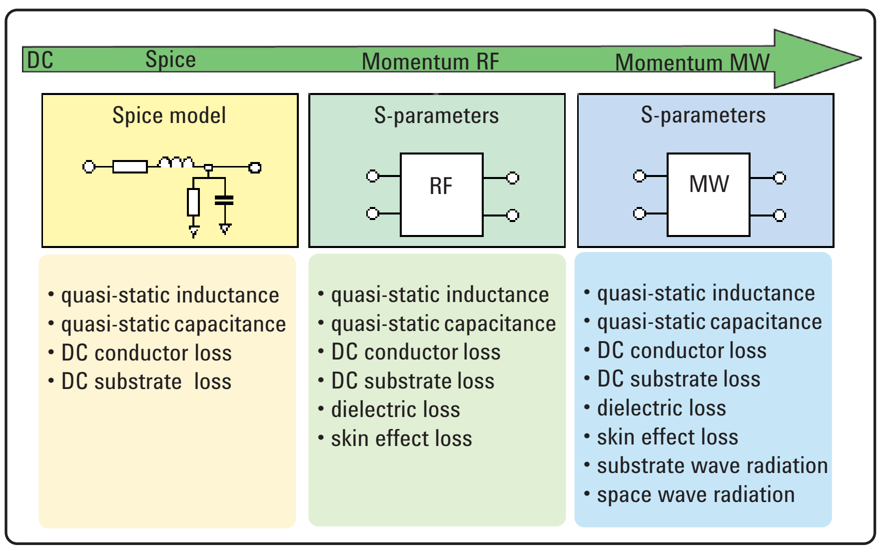
Designed to increase the simulation speed and reduce computer memory requirements, Momentum RF easily solves large geometries important to the communications industry.

Structures under a half wavelength are best solved by the quasi-static Momentum RF mode because it allows you to neglect loss mechanisms such as space and substrate radiation.

You can use the accelerated solution time available in Momentum RF to solve:

- large structures at low gigahertz frequencies such as ball-grid arrays, multi-layer LTCC and RF PC Board
- small structures at very high gigahertz frequencies such as MMIC and RFIC

Quasi-static vs. Fullwave Electromagnetics



Momentum RF Improvements

Three improved technologies converge with Momentum RF to give efficient solutions for structures critical to RF and RFIC designers:

1. Quasi-Static Solver

Provides faster solve times retaining accuracy for large structures.

2. Star-Loop Basis Functions

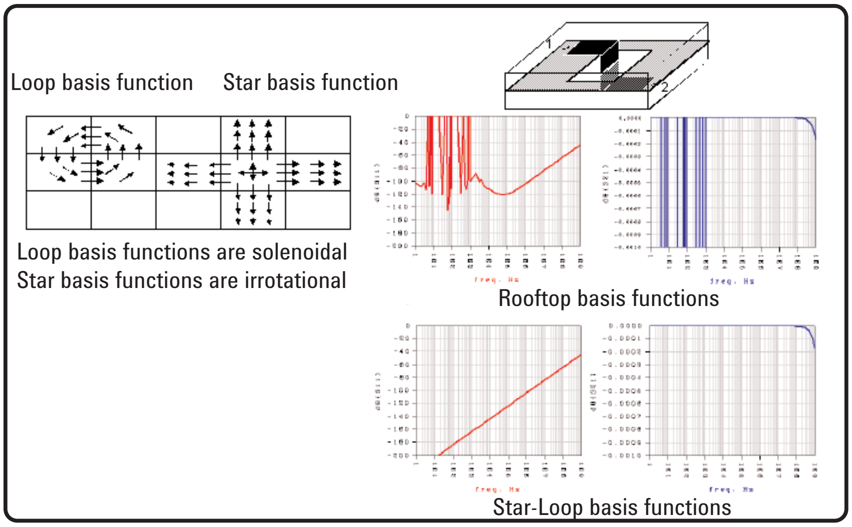
Performs stable solutions for magnitude and phase down to DC, resulting in a well-conditioned interaction matrix at low frequencies. This eliminates low frequency breakdown of numerical solutions, common to many method-of-moment solvers.

3. Mesh Reduction with Arbitrary Polygon Cells

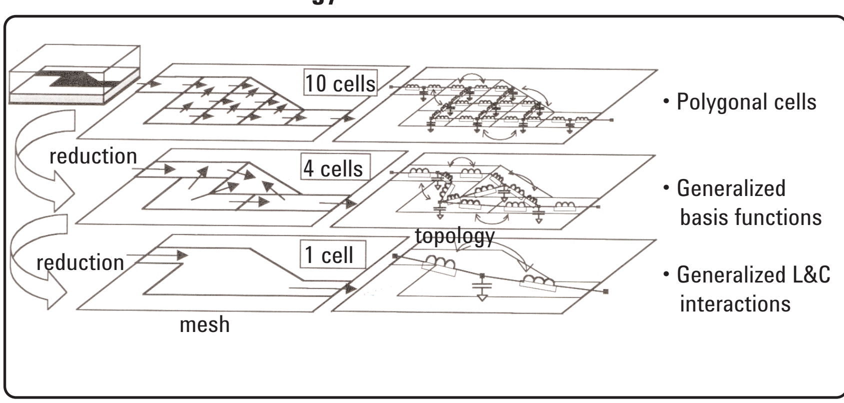
Reduces computer memory use and computation time while performing meshing of complex geometries with fewer cells. Arbitrary polygonal shaped cells are also easily solved with generalized basis functions. Low-quality slivery cells are eliminated with uncompromised accuracy for RF frequencies.

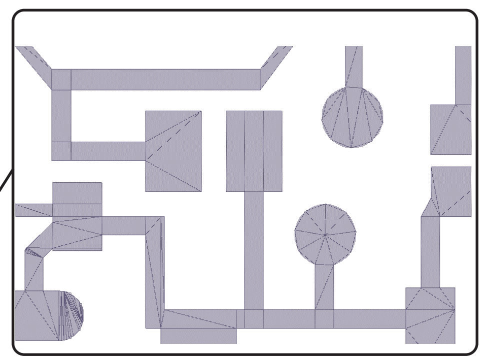
Star-Loop Technology

Stable solutions down to DC

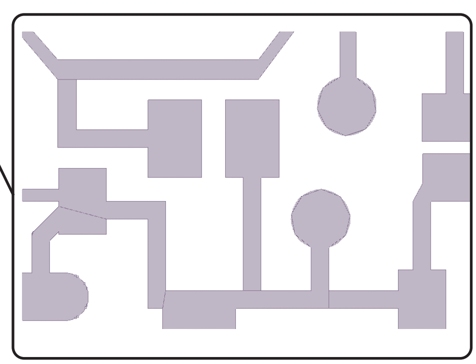


Mesh Reduction Technology

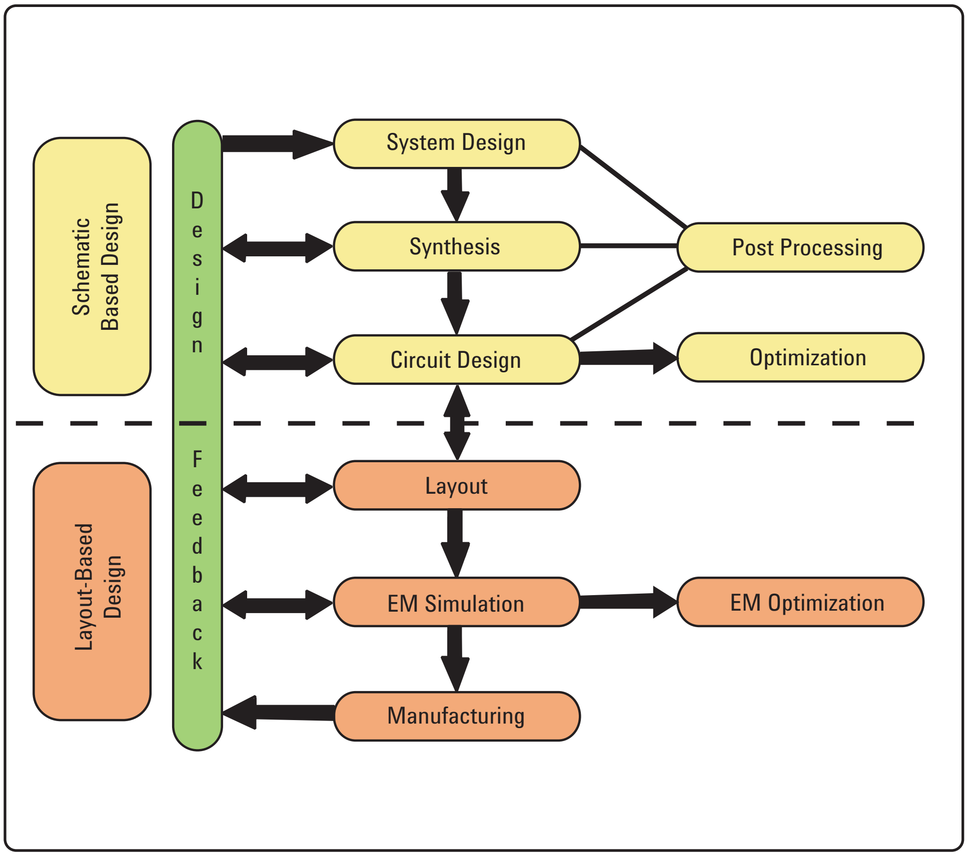




Momentum without mesh reduction technology.



Momentum RF mesh after reduction joins cells for more efficient solutions and eliminates low-quality slivery mesh.



Momentum Optimization fits into a typical design flow by providing layout-based optimization of geometries.

Momentum Optimization E8925A/AN (Optional)

Momentum Optimization takes EM simulation technology from simple analysis and verification to true design automation. This easy-to-use, automated, geometry-based technique lets designers fine-tune circuit performance. Designers can now explore design variations that used to be possible only after a time-consuming and inefficient process.

Streamlined, Automated Process

The efficiency of the Momentum Optimization process is unequaled in today's design environments. Typical EM simulation tools require the designer to return to the computer after each simulation, interpreting the results and manually changing the structure's geometry in the search for optimal performance.

Because the Momentum Optimization routine can automatically change and simulate the candidate variables to determine the best circuit performance, it frees the designer to focus on other tasks.

The optimization session consists of these general steps:

1. **Creating a Momentum design for the nominal structure,** with its substrate definitions, metalization data, and port types and mesh parameters.
2. **Defining geometric parameters as candidates for optimization.** For each parameter, give a starting value, a perturbed value, and lower and upper bounds for the parameter.
3. **Defining the optimization goals,** such as a not-to-exceed dB value for the magnitude of S_{11}, using the Design Specifications Editor.
4. **Running the optimization.** The optimizer runs without intervention, automatically varying and simulating the candidate variables to meet the specified goals.

If the designer requests it, the software back-annotates the starting values with the optimal values.

Geometry Capture

Setting up geometric parameters as candidate variables for optimization is easy with the geometry capture feature of Momentum Optimization. With geometry capture, the designer simply identifies a parameter to optimize. The software automatically creates a copy of the nominal design in a new layout window. The designer then edits the layout, and the software automatically translates the parameter value into the corresponding geometrical coordinates.

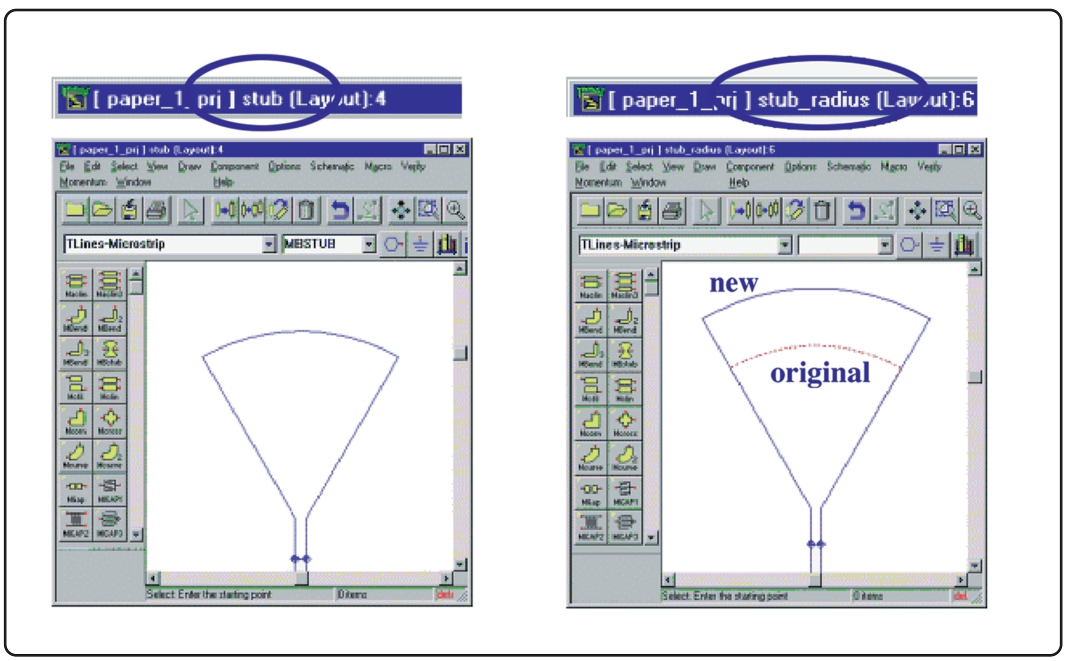
Comprehensive Set of Optimizers

Momentum Optimization employs a comprehensive set of optimizers, including least squares, minimax, quasi-Newton, random, and simulated annealing algorithms. All of these optimization technologies have proven track records in engineering applications.

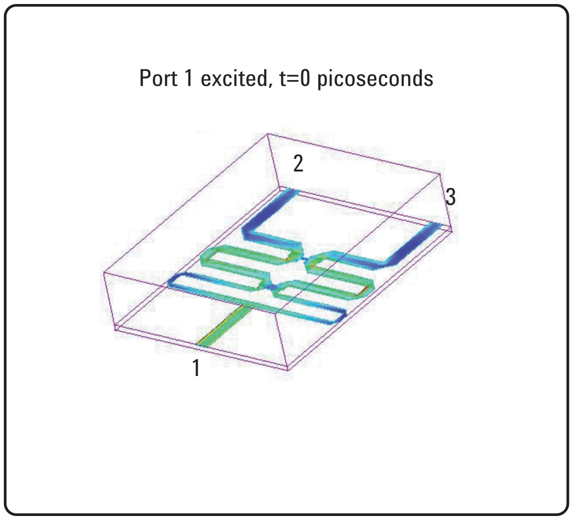
Interpolation for Speed and Efficiency

Momentum Optimization employs interpolation to significantly enhance its efficiency. The optimizer invokes Momentum for EM simulation only if the parameter value is moved across a user-specified interpolation interval. For small changes in parameter values, interpolation is applied instead of EM simulation to obtain S-parameters. This can substantially reduce the amount of time it takes to run an optimization, without compromising the accuracy of the results.

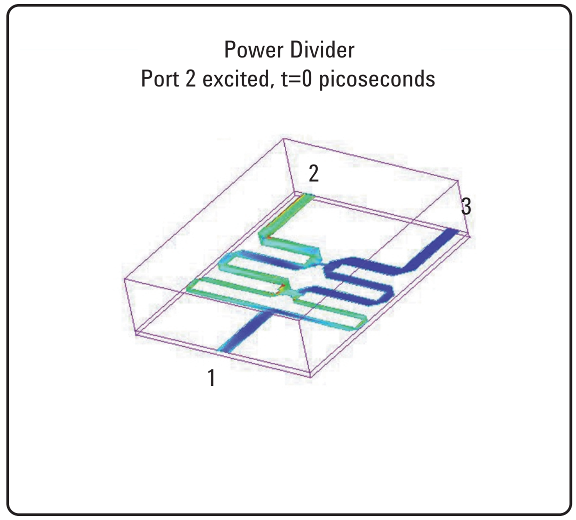
Nominal Geometry **Perturbed Geometry**



Geometry capture is defined as the difference in the location of vertices of a nominal design to a perturbed design. The layout of the perturbed design is automatically created when a new parameter is added to the nominal design. The name of the new layout is automatically appended with the name of the variable.



A two-section Wilkinson power splitter is driven from the common port and produces matched phase, equal amplitude signals at the two output ports.



The Wilkinson power splitter is driven from the output port 2, and the isolation of port 3 is shown.

Momentum Visualization E8922A/AN (Optional)

Momentum Visualization gives users of a 3D perspective. Visualization allows users to view and animate current flow in conductors and slots. For antenna designers, it also provides plots of 3D and 2D far-field antenna patterns and calculates and displays antenna parameters.

Designers can view and analyze the following simulation data:

- S-parameters
- E-fields
- H-fields
- Gamma constant
- Characteristic impedance

Plot formats include:

- S-parameter magnitude plot
- S-parameter phase plot
- Smith Chart
- 3D shaded, contour, and arrow field plots
- 2D line field plots
- Gamma plot
- Impedance plot
- 2D and 3D far field plots

3D Geometry

To produce a 3D spatial representation of circuit geometries, an Agilent Advanced Design System layout combines with the Momentum substrate definition, which defines substrate thickness and layer. Momentum Visualization gives the designer interactive control to dynamically zoom, pan, and rotate the 3D geometry to gain a better spatial understanding of the layer and conductor stack.

Animated Current

Surface current visualization gives designers an intuitive understanding of the electrical performance of the structure. Designers can even rotate structures in space while viewing animated plots to gain the best perspective. By sweeping the phase through the input source, the traveling and standing waves can be viewed as they are animated through the structure. Designers can also set the amplitude and phase of sources at multiple ports to view how signals combine.

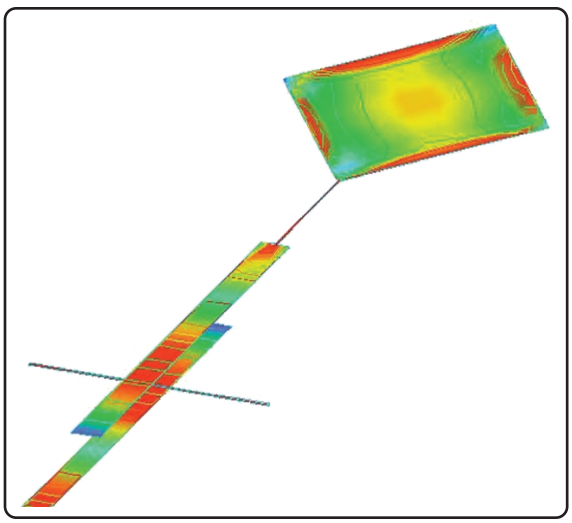
Far-Field Antenna

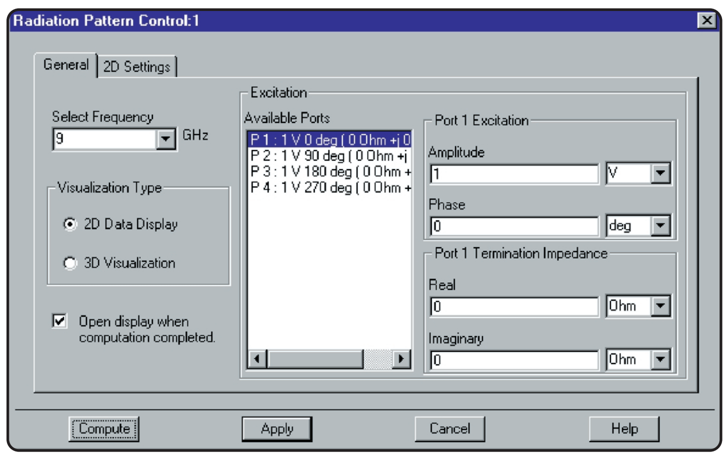
Antenna designers can display 3D far-field plots, which illustrate beam shapes and side lobes in both azimuth and elevation, on a single plot. The software calculates a number of antenna parameters, including:

- radiated power
- directivity
- gain
- maximum intensity
- axial ratio
- left-handed and right-handed polarization
- co- and cross-polarization

Far-Field Plots

Some circuits, such as patch antennas, benefit from the open-boundary condition of Momentum, which accurately accounts for radiation loss. Far-field plots are available for viewing antenna patterns.





The corner-fed microstrip patch antenna has an aperture-coupled microstrip feed. Maximum coupling through the aperture occurs in the magnetic field, one-quarter wavelength back from the microstrip open circuit. Momentum Visualization verifies the location of the maximum coupling field.

Momentum Circuit Designer Suite E8919A

For PC Users

Momentum Circuit Designer is a software suite that runs on PCs. Momentum helps you save design time by allowing you to perform electromagnetic analysis, layout, and linear analysis of your communication designs in a single, completely integrated environment.

Momentum Platform Compatibility

Momentum is supported on the following PC and UNIX platforms equipped with Agilent Advanced Design System 1.5:

- Intel/Pentium II 90MHz (or higher) CPUs running Windows® 95 or Windows NT® 3.51 or 4.0.
- The availability of Momentum for the PC platform is a new feature of Momentum 3.0. The PC version has all the capabilities of the UNIX versions. HP workstations running 9.x, 10.2
- Sun workstations running SunOS 4.1.x, Solaris 2.5
  Momentum Circuit Designer Suite is supported on the following PC platform:
- Intel/Pentium 90MHz (or higher) CPUs running Windows® 95 or Windows NT® 3.51 or 4.0.

System Requirements

To effectively run Momentum, your system should meet these specifications:

- 64 (minimum) MB of RAM for Windows® 95; 128 MB for Windows® NT
- 300 MB hard disk space for normal program installation 600 MB additional to install online documentation
- CD-ROM drive
- SVGA graphics card and 15-inch monitor

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