High Frequency Electromagnetic Software

SONNET® Suites Release 11

SONNET®

Powered By

Leading the Way in
High Frequency Electromagnetics

A Word From Our President

Biography:

James C. Rautio received a BSEE from Cornell in 1978, a MS Systems Engineering from University of Pennsylvania in 1982, and a Ph.D. in electrical engineering from Syracuse University in 1986. From 1978 to 1986, he worked for General Electric, first at the Valley Forge Space Division, then at the Syracuse Electronics Laboratory. At this time, he developed microwave design and measurement software, and designed microwave circuits on Alumina and on GaAs. From 1986 to 1988, he was a visiting professor at Syracuse University and at Cornell. In 1988 he went full time with Sonnet Software, a company he had founded in 1983. In 1995, Sonnet was listed on the Inc. 500 list of the fastest growing privately held US companies, the first microwave software company ever to be so listed. Today, Sonnet is the leading vendor of 3-D planar high frequency electromagnetic analysis software. Dr. Rautio was elected a fellow of the IEEE in 2000 and received the IEEE MTT Microwave Application Award in 2001 and is an adjunct professor at Syracuse University.

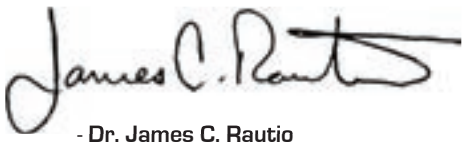
In addition to my own personal research, I have recently been presenting a number of technical seminars as well as lecturing on the life of James Clerk Maxwell. As of this writing I have presented the Maxwell lecture 61 times to a total of 3500 people. When I show images of Maxwell during these lectures I always mention Maxwell's eyes. His eyes show wonder, clarity, and excitement at the world around him. Suddenly we realize why Maxwell was able to see what others could not even guess as he developed that set of simultaneous differential equations that we today call Maxwell's equations.

During my technical seminars, I describe some of the latest, most advanced design techniques, some of which are useful even to those who might not yet use Sonnet. While I do this, I also look at the eyes of those in my audience. Sometimes it happens when I describe simple, but advanced design closure techniques that are hundreds of times faster than brute force EM optimization. Sometimes it happens when I describe a fundamentally new feature of Sonnet, like Co-calibrated Ports. When they suddenly realize that something new, something of great significance has happened, that is when I see that same excitement, that same wonder that I see in Maxwell's eyes.

Maxwell had no children, he has no direct descendents. But when I see my audience's eyes light up just like Maxwell, I realize that we are really all Maxwell's children. We are his descendents, through his work, sharing his excitement and wonder at this incredible world. And together, we can also achieve his clarity, understanding the amazing world descended from his equations.

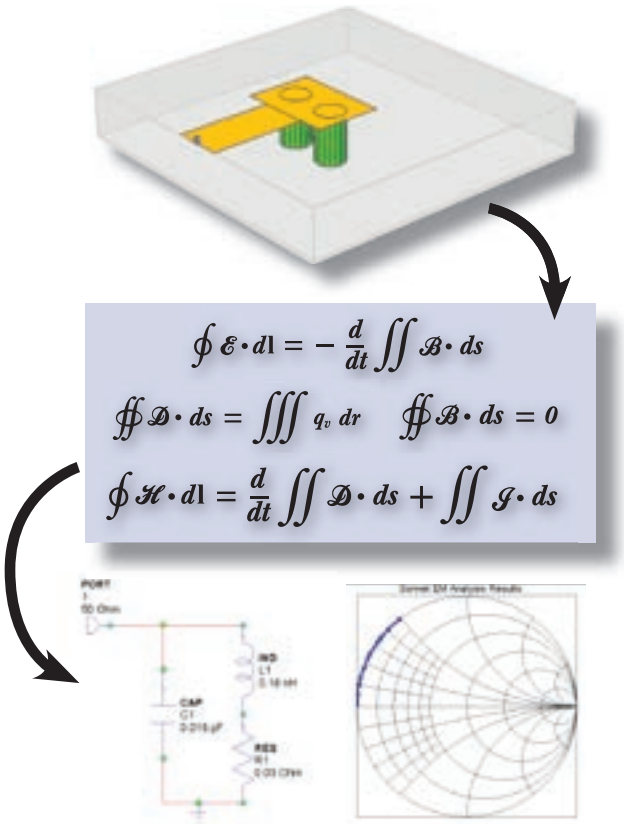
As you peruse this flyer, you will see multiple major advances. But one new capability will, as you come to understand it, stand above all others. We modestly call it "Co-calibrated Ports". These are internal ports that are perfectly calibrated (i.e., de-embedded). This is a completely new concept in high frequency EM analysis. As you take a few minutes to understand this brand new capability and consider its implications as described in this flyer, I am sure you too will share the excitement I have seen in those to whom I have personally described this major development.

As those around you start to understand the significance of this event, be sure to watch their eyes. And you too will see, we are indeed all Maxwell's children.



- **Dr. James C. Rautio**
CEO and President
Sonnet Software, Inc.

Why EM?



Full-wave Electromagnetic Analysis and Model Extraction
(Maxwell's Equations form the basis for Electromagnetic Analysis)

Cost-Effective Virtual Prototyping

High frequency electromagnetic (EM) simulation gives you virtual measurement results on a high frequency design before you spend considerable time and money to build or fabricate. A promising design can be fine-tuned using swept-parameter analysis, EM-based optimization, and EM-generated electrical extraction models in higher-level circuit theory design and optimization. This means that you build with confidence of success... the first time.

When accurate circuit models are not available or circuit model parameters are out of range...

Model based circuit simulators are based on empirical models for a specific application (like simple microstrip or stripline), with limited valid ranges for physical dimensions. In addition, only selected circuit geometries, substrate types and substrate parameters are supported with available models. Stretching the existing models to materials or dimensions beyond their validity introduces significant error, and error that is very difficult to quantify until after your part is built and measured. EM-based model extraction handles extreme geometries or materials with ease.

Whenever a layout feature cannot be described by a circuit model...

The physics-based analysis in Sonnet Professional will provide the answer. An example for this could be a special inductor, capacitor or transformer which is not included in the foundry design kit. Sonnet can be used to analyze those components "on the fly" or generate a full library of component models with trustworthy electrical results. Sonnet gives you the power to explore new layouts to develop better components for your application than your competitors—faster than your competitors.

When parasitic coupling is present...

High frequency electromagnetic (EM) software makes the determination and correction of parasitic coupling possible—before you fabricate. Even elements which are considered "sufficiently" far apart can suffer from parasitic coupling. As frequencies rise, parasitics show up as inductive or capacitive coupling between circuit elements or to ground, resonance effects due to poor ground construction, parallel-plate mode propagation, or packaging mode resonances. Sonnet's analysis is based on the physical properties of your technology and will account for such physical effects—all of them.

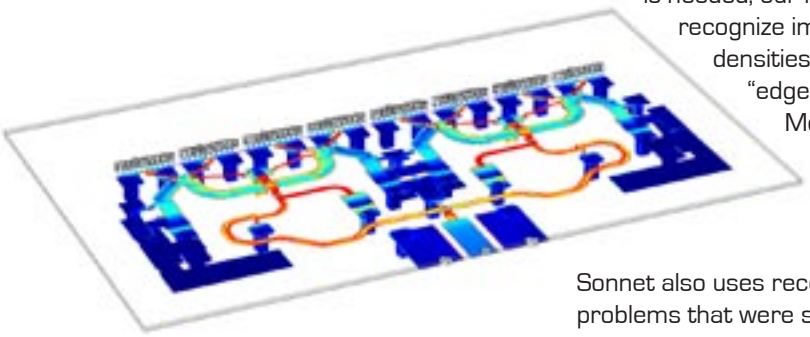
When interconnects and traces become "electrically active"...

At low frequencies, traces and vias that interconnect surface mount components act just the way they should—perfect wires in your schematics. However, when frequencies get higher, these traces and vias begin to act like distributed inductors, capacitors and resistors. Electromagnetic cross-coupling from one trace to another transfers energy to unintended parts of the circuit. At high enough frequencies, these distributed circuit layout effects can completely kill a design. EM analysis can effectively test your layout at any frequency—telling you how your interconnects and vias will affect the performance of your finished product—before you fabricate or etch.

Why Sonnet?

High Accuracy

Sonnet is synonymous with Accuracy for high frequency 3D planar EM analysis. Using the Shielded Domain Method of Moments technique, Sonnet consistently provides model extraction error on the order of 1% or less, and is the only high frequency EM tool capable of consistent, reproducible error of under 0.1% for precise design challenges. For over 20 years, Sonnet has been dominant in high-accuracy analysis of planar circuits and interconnects in RFIC, MMIC and high density packaging applications at frequencies from 1 MHz through 2 THz.



Interfaces to Your Design Flow

We know it is essential to work within the high frequency design flow in which you are invested, without forcing you to use restrictive proprietary environments. Sonnet provides seamless, error-free interfaces to work within major high frequency CAE design frameworks such as Cadence, Agilent EEsof's Advanced Design System (ADS) and GENESYS™ Suite, and Applied Wave Research's Microwave Office® (MWO) and Analog Office™ (AO). This gives you the freedom to work the way you want, while minimizing translation errors between the tools.

Fast and Efficient for Demanding Applications

In the early years of high frequency design, electromagnetic simulators were difficult to use and time-consuming for extraction of even the simplest models. Today, Sonnet provides fast and efficient planar EM simulation through such technologies as Adaptive Band Synthesis (ABS), and use of the fast-Fourier transform (FFT) for circuit cross-coupling evaluation. With today's 64-bit processors and Sonnet's ***emCluster®*** Computing technology, it's now possible to test the layout of an entire MMIC or RFIC in a couple of hours.

Easy to Learn

Learning to use new analysis and model extraction tools can be difficult. Sonnet removes confusion through an intuitive design, clear tutorials, a quick-start guide to give you step-by-step feedback in model creation, and helpful on-line help. In addition, Sonnet Lite is a no-cost path to fast learning and applying EM analysis to small EM problems.

Advanced Meshing Technologies

Sonnet provides automatic meshing of circuit geometries, with special attention to potential problem spots in your circuits. No adaptive meshing is needed; our meshing algorithms have been carefully tuned to recognize important circuit features that require higher meshing densities. Edge meshing of transmission lines to capture the "edge current" effect is critical to obtaining accurate results. Meshing must be carefully considered for cross-overs and unders, and around circuit discontinuities. Sonnet automatically sets the mesh to capture circuit current behavior in these regions without user intervention.

Sonnet also uses recent advances in meshing technology to solve problems that were simply impossible only a few years ago. With our patented Conformal Meshing technology, Sonnet makes easy work of curved geometries and off-grid circuit elements with built-in edge current consideration for high accuracy models—with a small fraction of the memory and time required of rectangular meshing techniques.

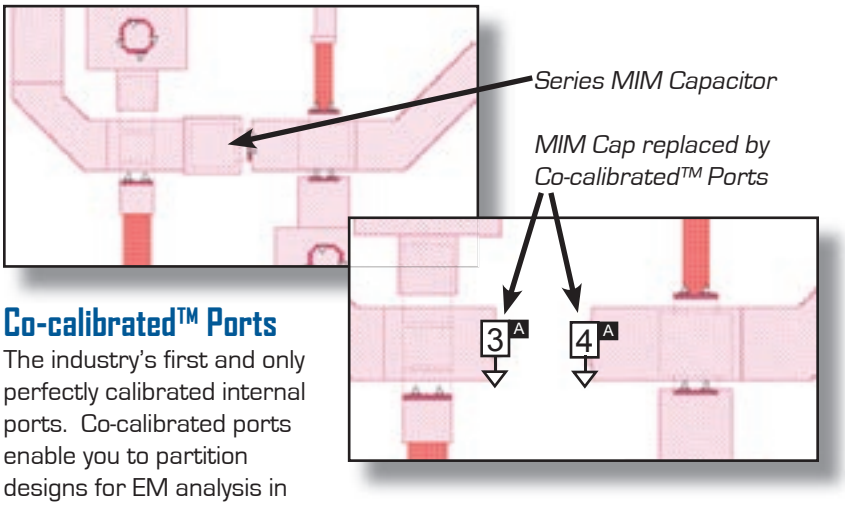
Advanced EM Port Technologies and Superior Calibration

One of the biggest challenges in measuring real circuits is getting the signal into and out of the device while removing the discontinuity of the transition or feed. Similarly, high frequency EM software uses ports to apply signal to the circuit, or read the signal levels from the circuit. Ports introduce non-physical discontinuities which must be calibrated out of the results, or they will add significant error to the extraction model.

Sonnet's port calibration techniques are the most accurate in the industry, providing reliable S-parameter dynamic ranges that meets or exceeds 100dB. (Imagine your network analyzer with such dynamic range!) With Sonnet's edge ports, and now with our new Co-calibrated™ Ports,

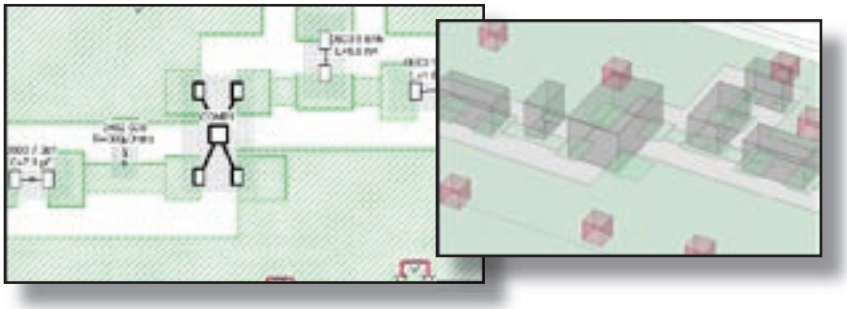
New Features in Release 11

- Co-calibrated™ Ports
- Components for SMD model inclusion for EM analysis
- 64-bit EM Analysis Engine for AMD/Intel Processors
- Sonnet Cluster Computing
- Totally redesigned and enhanced Agilent ADS Interface
- Enhancements to the AWR® Microwave Office® Interface to accommodate Remote EM processing, *emCluster*® Processing and thick metal modeling



Co-calibrated™ Ports

The industry's first and only perfectly calibrated internal ports. Co-calibrated ports enable you to partition designs for EM analysis in ground-breaking new ways. Co-calibrated ports provide accurate model attachment points for active and passive devices in electrical simulations.

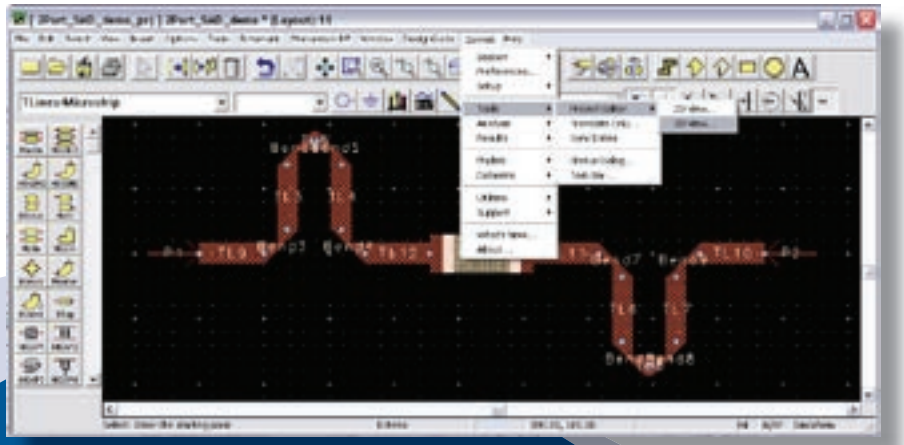


Components

Electrical model objects that can be embedded into your EM projects. Leveraging our new Co-calibrated™ Port technology, Components can be ideal lumped elements, device measurements, or surface mount device (SMD) vendor models for transistors, amplifiers, discretes and more. Components take the guess work out of SMD pad and terminal parasitics.

64-Bit EM Analysis Engine

EM analysis engine upgrade now enables job sizes exceeding 4GB. Job size is now limited only by the physical RAM memory on your Intel®/AMD® processor-based computer. Release 11 EM analysis engine is up to 40% faster for Intel and AMD processor platforms.



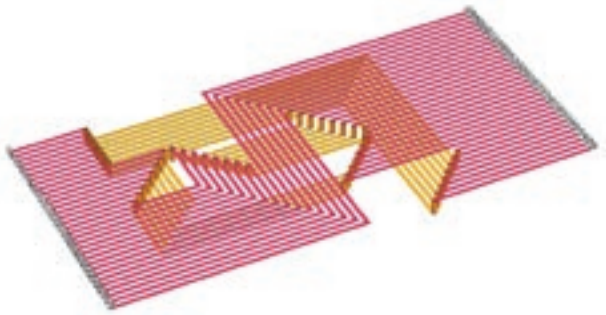
Agilent EEsof ADS Interface

Use Sonnet as an EM model extraction client for ADS. Entirely within ADS, the interface automatically provides layer mapping of ADS drawing layers to Sonnet geometry models and invokes EM simulation. It also creates ADS Design Kit models that include dataset, layout and a layout look-alike schematic symbol for ease of use in ADS schematics.

Applications

Signal Integrity

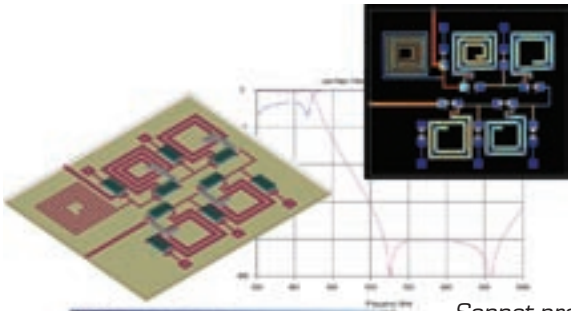
Quickly and accurately model high-speed buses and circuits with signal integrity concerns. Sonnet imposes no limits on layers, ports or number of traces in the circuit. Compute all cross-talk, loss and self-parasitic effects in your circuit.



Extract 64-port SPICE/PSPICE Model

PCB

PCB low-pass filter application with printed inductors. Sonnet provides EM modeling of all layout details, including parasitics and cross coupling. S-parameter or lumped element models for surface mount devices can be easily incorporated into the EM simulation using Sonnet's unique Co-calibrated™ Internal Ports and netlist. This yields a high-confidence model for the complete circuit.

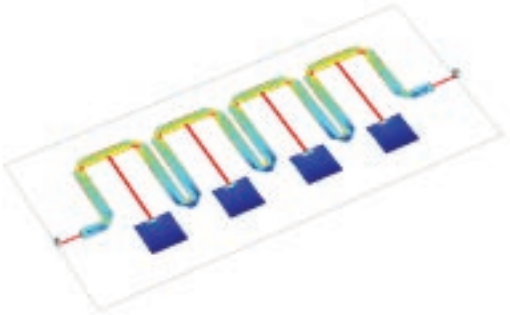


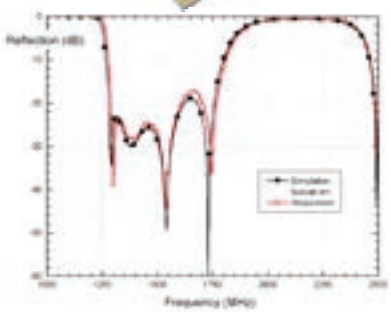
Sonnet provides precise assessment of grounding or signal integrity problems. High current density in the local ground region shows the effects of a detrimental local resonance between top and bottom ground planes.

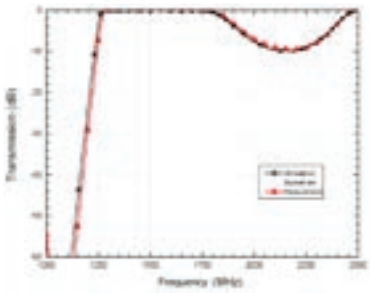
Superconductors

Superconducting filter design modeled in Sonnet for a radio astronomy application.* Measurements on the part demonstrate excellent agreement to the Sonnet simulations; Sonnet enabled a first-pass success for the filter. Current density is shown at 1.5 GHz.

** At the Max Planck Institute of Radio Astronomy.*

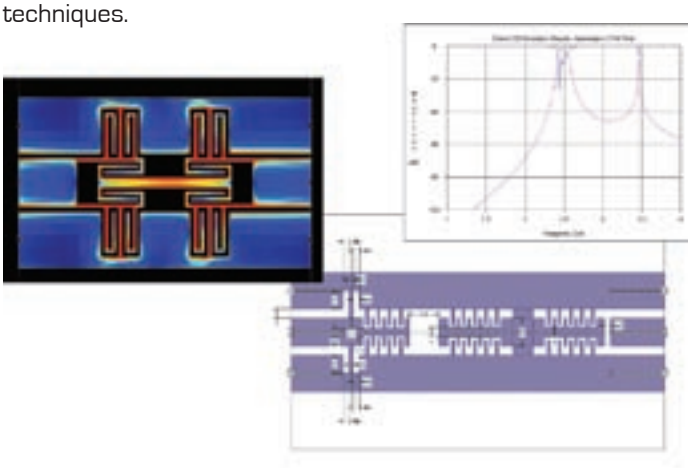






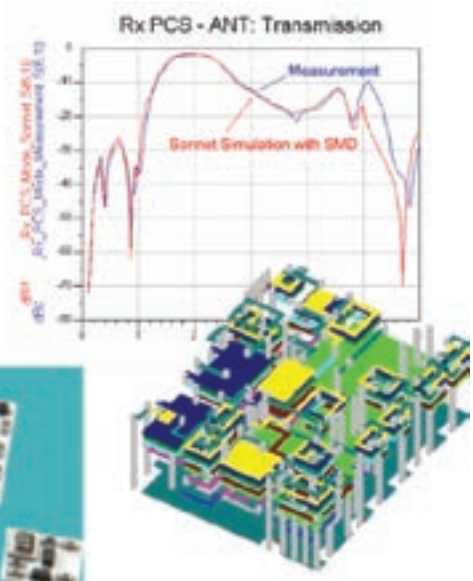
CPW

Finite ground coplanar waveguide (FGCPW) filter analysis using Sonnet. Narrowband design shows a package-induced resonance at 3.46 GHz unanticipated by conventional filter design techniques.



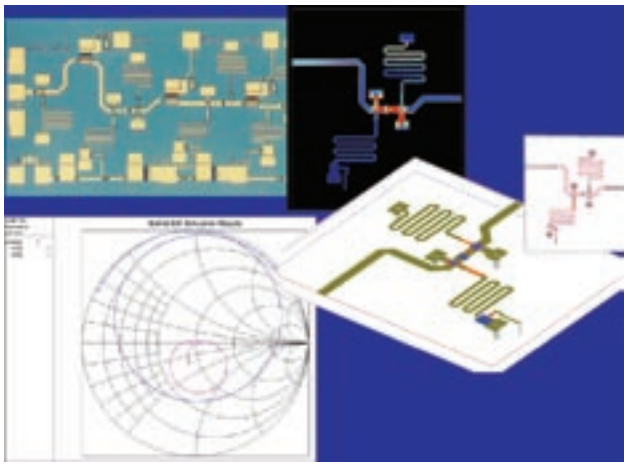
LTCC

Sonnet provides the industry's most efficient handling of multi-layer LTCC structures, some of which exceed 20 layers of conductors.



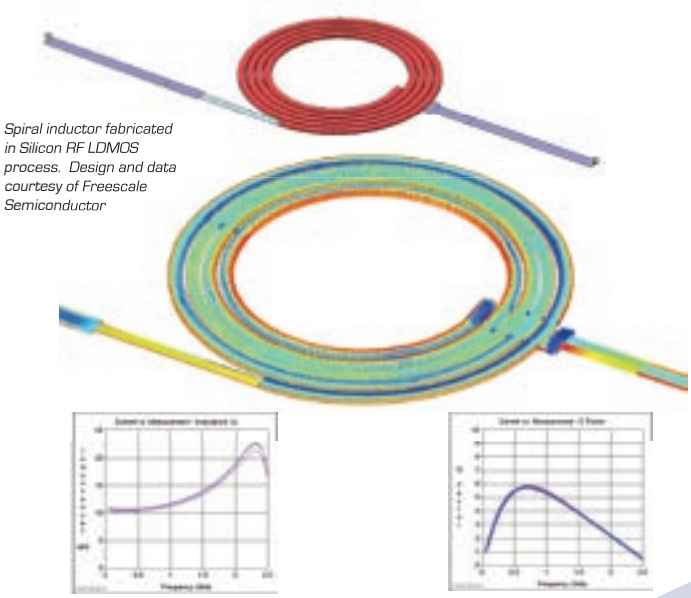
MMIC and RFIC

Sonnet computes response and current density of the interstage matching network from 10-30 GHz. Current density pictured at 19 GHz. Only 8 EM simulation frequencies are required for Sonnet's ABS technique to provide a wideband frequency sweep. Sonnet excels in the thin dielectric and short via simulation requirements often found in MMIC and RFIC applications.



Spiral Inductor Design

Sonnet's Conformal Mesh gives excellent results for this thick metal spiral while greatly reducing the time and memory required for the simulation.

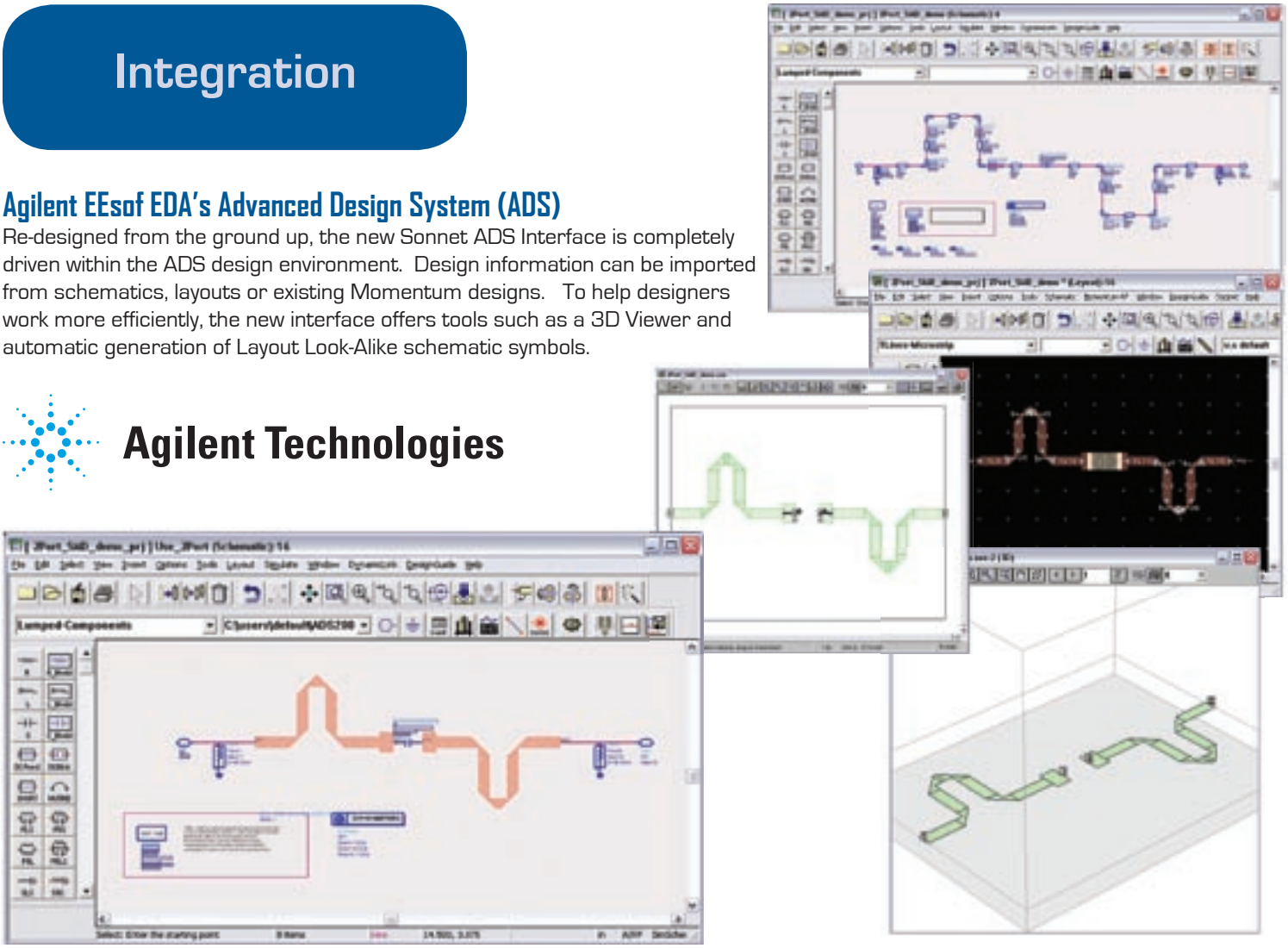


Spiral inductor fabricated in Silicon RF LDMOS process. Design and data courtesy of Freescale Semiconductor

Integration

Agilent EEsof EDA's Advanced Design System (ADS)

Re-designed from the ground up, the new Sonnet ADS Interface is completely driven within the ADS design environment. Design information can be imported from schematics, layouts or existing Momentum designs. To help designers work more efficiently, the new interface offers tools such as a 3D Viewer and automatic generation of Layout Look-Alike schematic symbols.

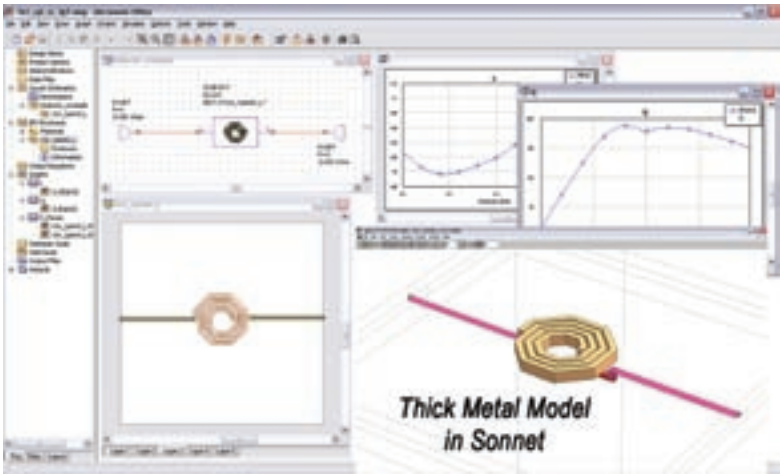


Agilent Technologies

AWR® Microwave Office®

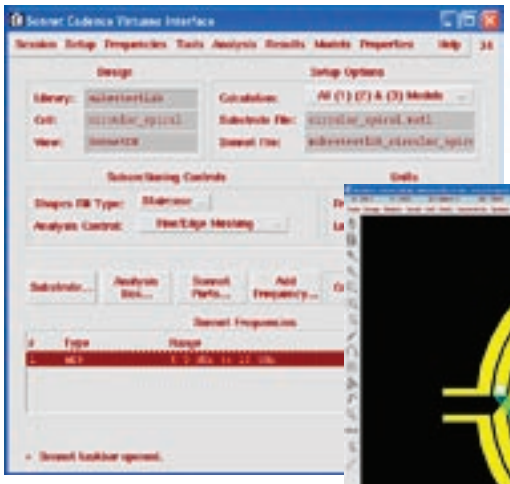
Sonnet EM Co-Simulation capability for AWR Microwave Office and Analog Office® EM projects. Full bi-directional geometry and data translation.

AWR

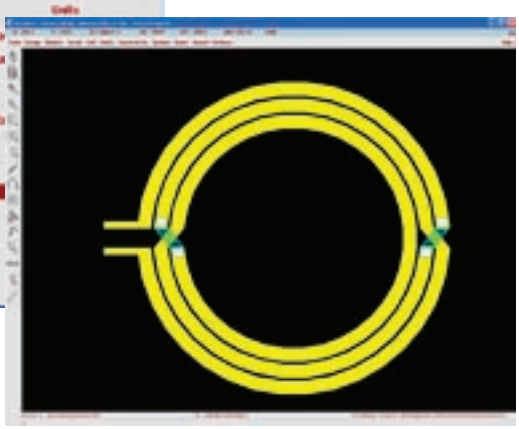


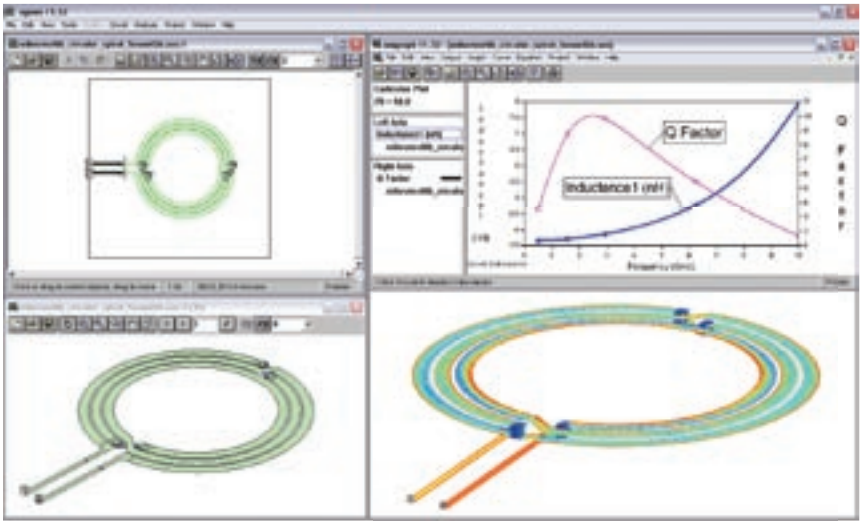
Cadence® Virtuoso®

Integration of this interface to the Cadence® Virtuoso® environment enables our customers to use Sonnet completely from within Cadence. Sonnet uses layout cells to quickly and seamlessly extract EM analysis projects based on your Cadence technology files and process information. Model data views (including Spice extraction models) are automatically generated and installed in your library, available for your choice of circuit analysis tool.



cadence™ CONNECTIONS





Typical Design Flow

Circuit Design Framework
AGILENT EEsof EDA's ADS
CADENCE® VIRTUOSO®
AWR® MICROWAVE OFFICE®
Eagleware GENESYS™

Bi-directional
Layout Geometry
Data Exchange

SONNET® Suites Professional™
Full-Wave EM Simulation

S,Y,Z-Parameter Models
Broadband Spice Models

Circuit Design Framework
AGILENT EEsof EDA's ADS
CADENCE® VIRTUOSO®
AWR® MICROWAVE OFFICE®
Eagleware GENESYS™

Interfaces also available for:

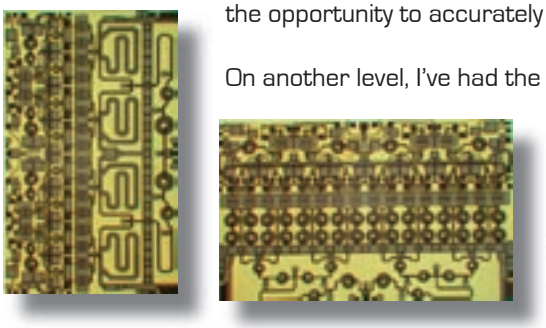
CST Microwave Studio®, Eagleware GENESYS™ from Agilent EEsof and CAD Design Software

CST

CDS CAD DESIGN SOFTWARE

Customer Comments

"**Sonnet is an integral part of my MMIC design process.** Whether relatively 'simple' structures such as folded or meandered microstrip lines or merged elements such as MIM capacitors on transmission line junctions, process unique structures such as 3D spiral inductors or innovative drain buss networks or complex, compact, highly integrated MMIC-level elements, I trust Sonnet to provide me fast, accurate results with each analysis. And with each new release, Sonnet has provided me the opportunity to accurately analyze larger, more complex structures.



Designs Courtesy of Tyco Electronics

On another level, I've had the pleasure to work closely with and to call friends the Sonnet team. I know their personal dedication and drive to provide the most accurate electromagnetic analysis tools available...and to back up those tools with the highest level of support. They've delivered in both instances."

- **Michael Ashman**
  Senior Principal Engineer
  Wireless Systems Segment
  Tyco Electronics

"**The accuracy of the new Co-calibrated™ Port de-embedding in Version 11 is impressive, a truly enabling breakthrough for optimizing microwave and millimeter wave circuit performance.** We are now able to achieve more optimal designs in substantially less time. This is a great product!"

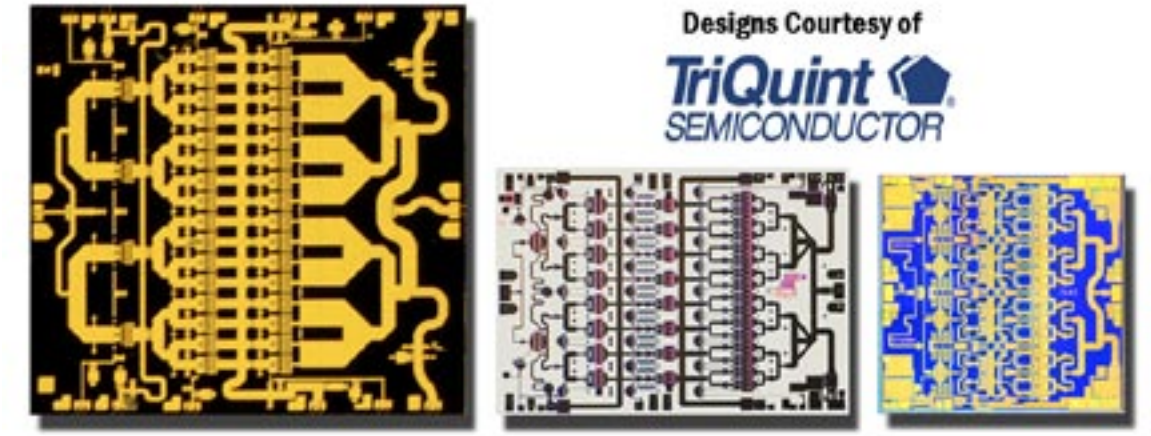
- **David Bates**
  Chief Scientist
  Dielectric Laboratories

"**My research group at UCSD relies on Sonnet for virtually all our EM simulations in RF MEMS, microwave and mm-wave RFIC design,** and for complicated filter development including channelizers with more than 20 ports. In RF MEMS, Sonnet is a very powerful tool capable of analyzing planar resonators with RF MEMS devices, even though there is more than 100x dimensional difference between the resonator and the RF MEMS switched capacitors. In RFIC, we have found that Sonnet consistently provides accurate inductance and Q prediction of planar spiral inductors and complicated 3-D transmission-line geometries on silicon, leading to "first-pass" circuit success. We use extensively Sonnet's multi-port features for filter optimization and RFIC design. For example, by placing extra optimization ports in our Sonnet models and integrating the results with a standard circuit simulator, we are able to quickly optimize RFIC designs. My graduate students also indicate that Sonnet's graphical user interface is the easiest they have ever used. **Sonnet is an integral part of our work and every graduate student in my group learns Sonnet.**"

- **Gabriel M. Rebeiz, Ph.D.**
  Dept.of Electrical and Computer Engineering
  University of California at San Diego

"A high performance process is only part of the complete picture; advanced MMIC design techniques are of equal importance. For a product to be competitive, it must demonstrate state-of-the-art performance at low cost. For a given process technology, the cost to manufacture the MMICs is reduced by minimizing the amount of GaAs real estate consumed by the die. This is accomplished with MMIC layout techniques for maximum circuit compaction followed by extensive numerical simulation to properly account for all electromagnetic (EM) interaction between components. As EM simulation tools and computing technology become faster and more advanced, larger portions of a design may be simulated, thus allowing the designer to more aggressively integrate circuits with increased confidence of actual performance that will be achieved. MMIC die area compaction is illustrated by TriQuint Semiconductor's Ka-band power amplifier product line. For example, consider the 4 W 30 GHz power amplifier MMICs shown above. The third generation product uses 3 times less GaAs wafer (die) area than the original with no sacrifice of electrical performance. In this particular case, **Sonnet was used to perform the full-wave electromagnetic simulation to successfully achieve this level of compaction.** Simulation tools like Sonnet Software have become an integral part of our design flow here at TriQuint Semiconductor and it is fast becoming one of the standardized EM tool sets within our design engineering group."

- **Charles F. Campbell, Ph.D.**
  Design Engineering Director
  TriQuint Semiconductor Texas



Size reduction for a 4W, 30 GHz power amplifier MMIC.
(Sizes shown are in relative scale)

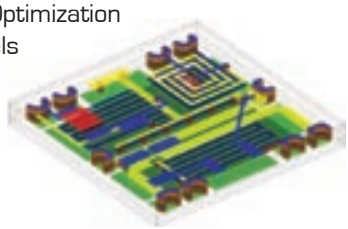
"Anokiwave relies on Sonnet to provide quality designs. In our experience of using Sonnet for over a decade, we have yet to find a case where the measurements have differed significantly from Sonnet's EM simulated expectations. Sonnet is an integral part of our design process. **Thanks to Sonnet, Anokiwave has been able to provide novel and quality designs that often meet first pass success.**"

- **NItin Jain, Ph.D.**
  Chief Technology Officer
  Anokiwave

SONNET® Suites

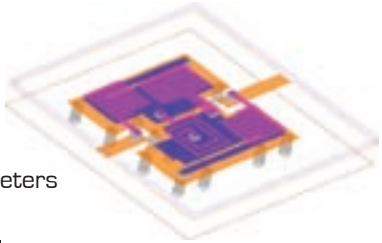
SONNET Professional™

- Unlimited Parameters for Sweep Analysis and Optimization
- Unlimited Memory, Ports, Dielectric, Signal Levels
- Conformal Meshing
- Internal Components and Co-calibrated™ Ports
- DXF, GDSII Import and Export
- Support for UNIX, Linux, and Windows
- 64-Bit EM Analysis Engine



LEVEL3 GOLD™

- 256 MB Memory Allowed
- 3 Signal Conductor Levels + Gnd
- Up to 8 Port Circuits
- Unlimited Ideal Internal Components
- Components for Vendor SMD Models
- Sweep Analysis and Optimization of 2 Parameters
- DXF Import/Export



LEVEL2 SILVER™

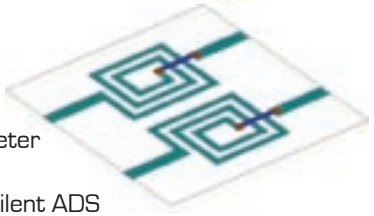
- 128 MB Memory Allowed
- 2 Signal Conductor Levels + Gnd
- Up to 6 Port Circuits
- Unlimited Ideal Internal Components
- Sweep Analysis and Optimization of 2 Parameters
- DXF Import/Export

LEVEL2 BASIC™

- 64 MB Memory Allowed
- 2 Signal Conductor Levels + Gnd
- Up to 6 Port Circuits
- Unlimited Ideal Internal Components
- Sweep Analysis and Optimization of 2 Parameters
- DXF Import/Export

LitePlus™

- 32 MB Memory Allowed
- 2 Signal Conductor Levels + Gnd
- Up to 6 Port Circuits
- 3 Ideal Internal Components
- Sweep Analysis and Optimization of 1 Parameter
- DXF Import/Export
- Interface to AWR® Microwave Office® and Agilent ADS



Lite™

- Create, Analyze and Save Arbitrary Planar Circuits
- 16 MB Memory Allowed
- 2 Signal Conductor Levels + Gnd
- Up to 4 Port Circuits
- 3 Ideal Internal Components
- Sweep Analysis of 1 Parameter
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