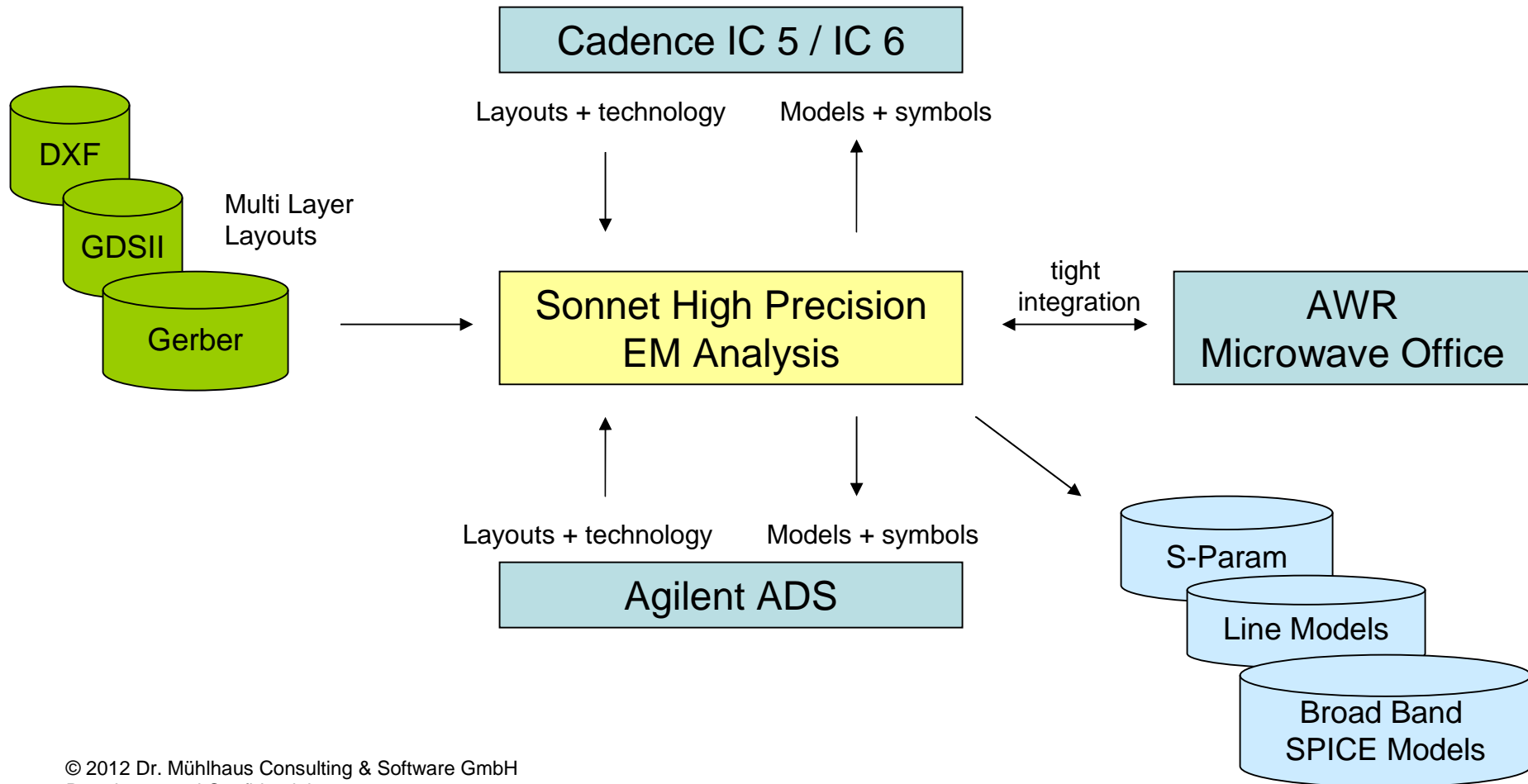


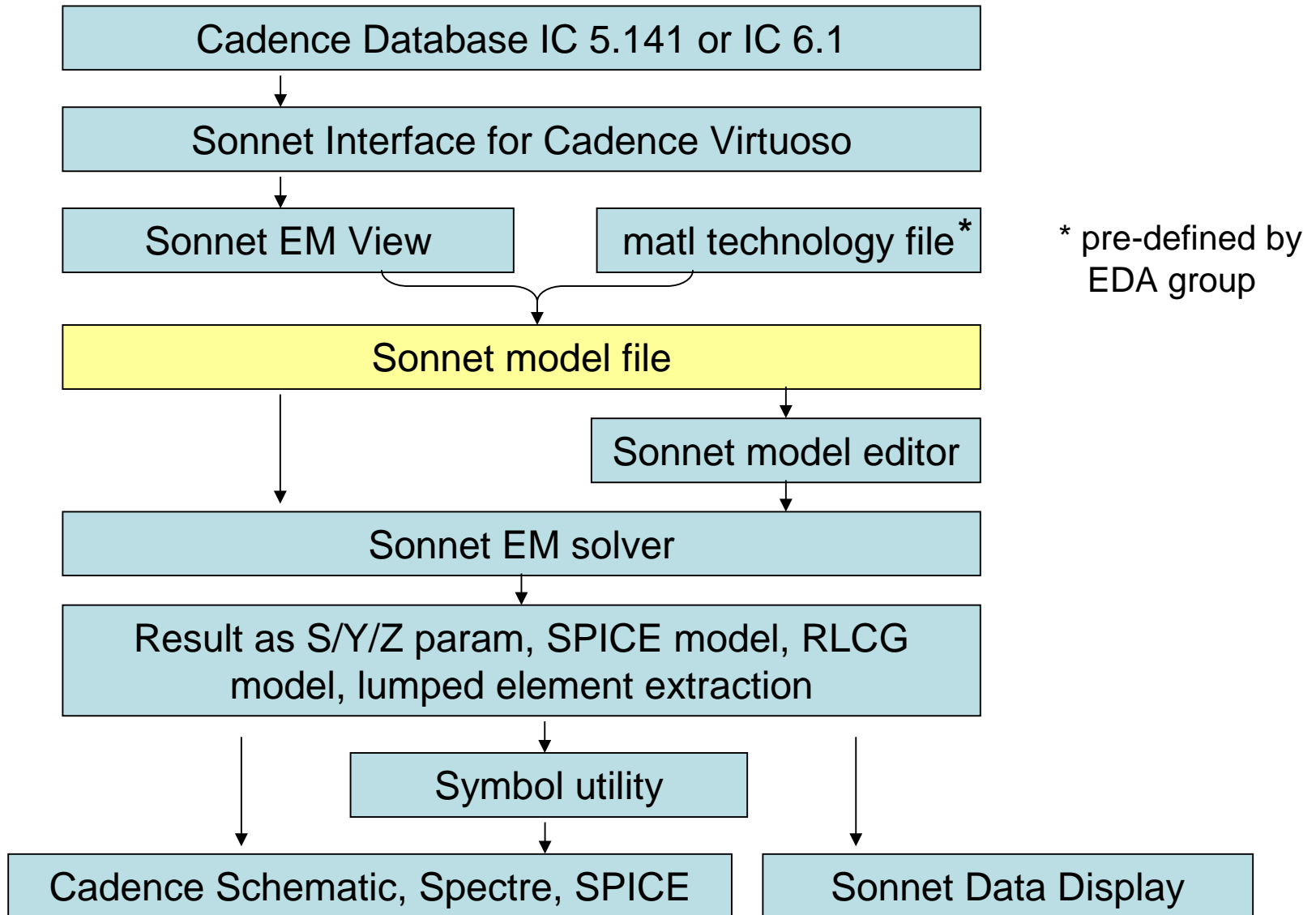
Sonnet High Precision EM for RFIC

Volker Mühlhaus
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Sonnet integrates into all major design flows



Design Flow Sonnet ↔ Cadence

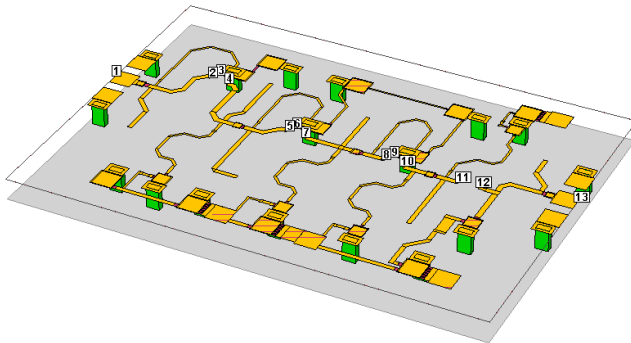


Why Sonnet?

- Sonnet is the **accuracy reference** in planar EM analysis
- **Avoid design respins**: Sonnet has an impressive track record in achieving "first time right" silicon for RF & mixed signal designs
- Sonnet **integrates into all major RF design flows**: Cadence IC5/IC6, Agilent ADS, AWR Microwave Office, or can be used stand alone
- Sonnet offers many output formats used in RFIC design, so that results can be used easily where you need them
- **Be more productive**: Sonnet is better integrated and easier to learn than so called "full 3D" solvers.
- **Scalable to your needs**: Sonnet is scalable from desktop solver to high performance simulation cluster

Why not "full 3D"?

- Sonnet is **more efficient** and **more accurate** for planar simulations.
- Lower acquisition, maintenance and training (easier to use) costs than "full 3D" solvers.
- The Sonnet solver calculates the **full 3D coupling** of complex layouts. Many problems in RFIC, mixed technology and packaging are planar and can be simulated with Sonnet.
- **Error from ports is a big issue with traditional 3D solvers.** In dense layouts, it gets even worse. The Sonnet accuracy is superior to traditional 3D solvers because of Sonnet's advanced port calibration.



De-Embedding the Effect of a Local Ground Plane in Electromagnetic Analysis

James C. Rautio, *Fellow, IEEE*

Abstract—In electromagnetic analysis of complex planar circuits, it may be necessary to use internal ports, for example, in locations where surface mount devices might later be attached. These internal ports require a local ground plane for ground reference when access to the global ground reference is unavailable. Even if perfectly conducting, use of such a ground plane still introduces excess phase in the local ground currents. This paper describes how to remove the effect of a lossy or lossless local ground, even including multiple closely spaced ports.

Index Terms—calibration, de-embedding, electromagnetic analysis, imperfect ground, low temperature co-fired ceramic, LTCC, planar circuit, surface mount device, SMD, surface mount technology, SMT.

I. INTRODUCTION

MOST high frequency and microwave circuit analysis makes use of ports and nodes. A port is two terminals

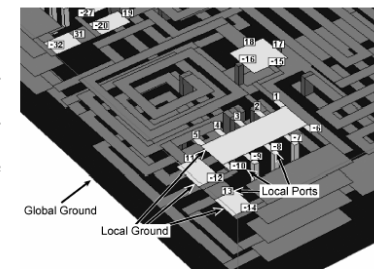


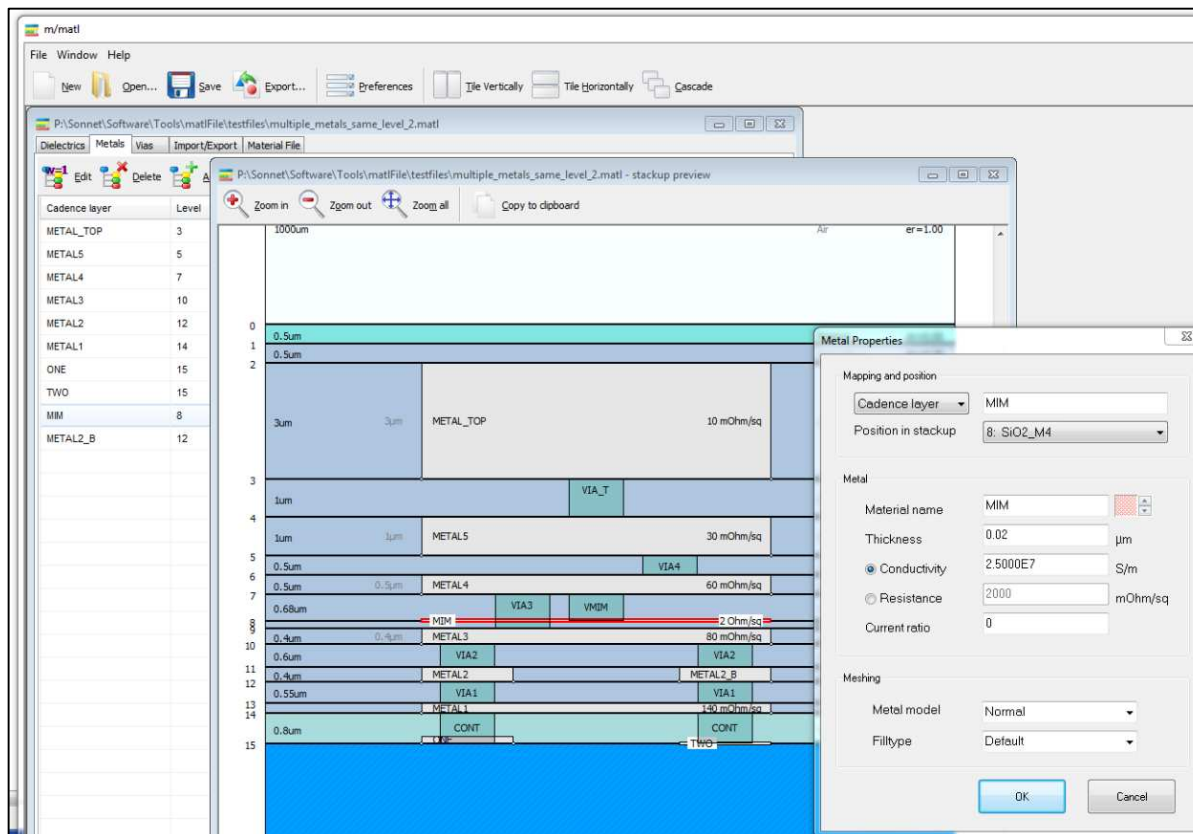
Fig. 1. An advanced LTCC circuit with topside internal ports for numerous

Ready for Mixed Technologies

- Sonnet is designed to handle mixed technologies
- Sonnet for mixed PCB + SiRF + Package technology is used with great success with our industry customers
- More efficient: Proven solution in dense layouts with many ports, where iterative "fast" solvers are getting slow and inaccurate.
- More accurate: Sonnet's CoCalibrated ports give superior accuracy for very dense packaging, where other EM solvers fail due to parasitic port coupling
- Mixed technology ready: no problem to handle thick & thin metal on the same layer
- Mixed technology ready: Sonnet handles extreme planar geometries. It can handle dielectrics that are tens of angstroms thick in the same problem where thick PCB layers might be included for chip and package stacking analysis.

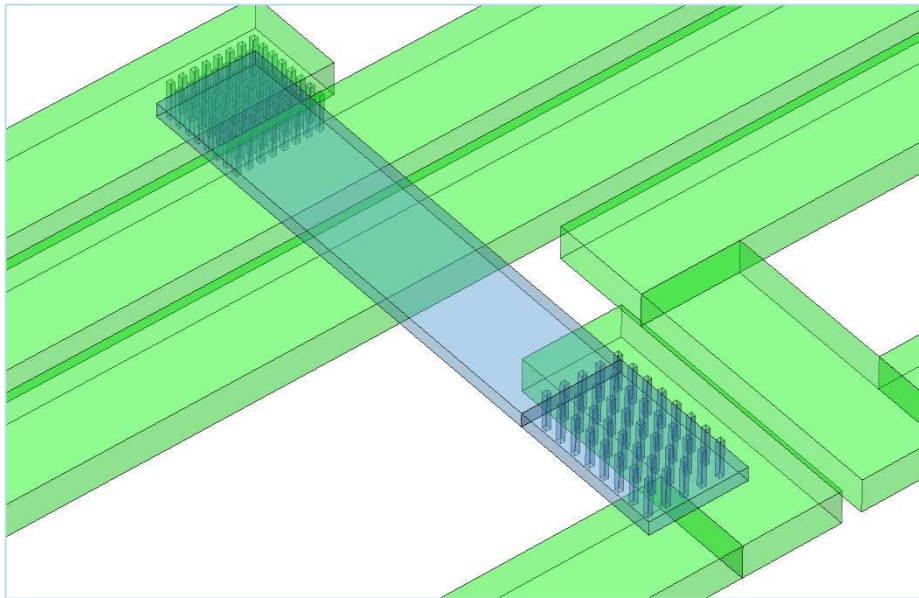
Intuitive Technology Setup

- Re-use **existing technology files** from Cadence or Agilent ADS
- An **intuitive technology file editor & viewer** is available from Mühlhaus

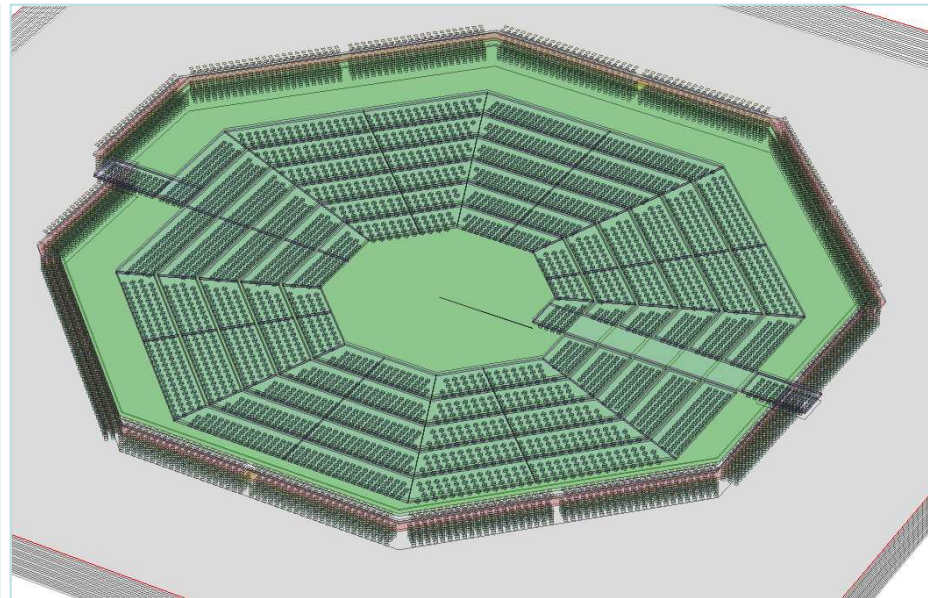


More productive

- **Automated** merging of micro via arrays, **keeping** the correct resistance
- Skill scripts to preprocess the layout before simulation: **simplify and clean up** complex metal planes



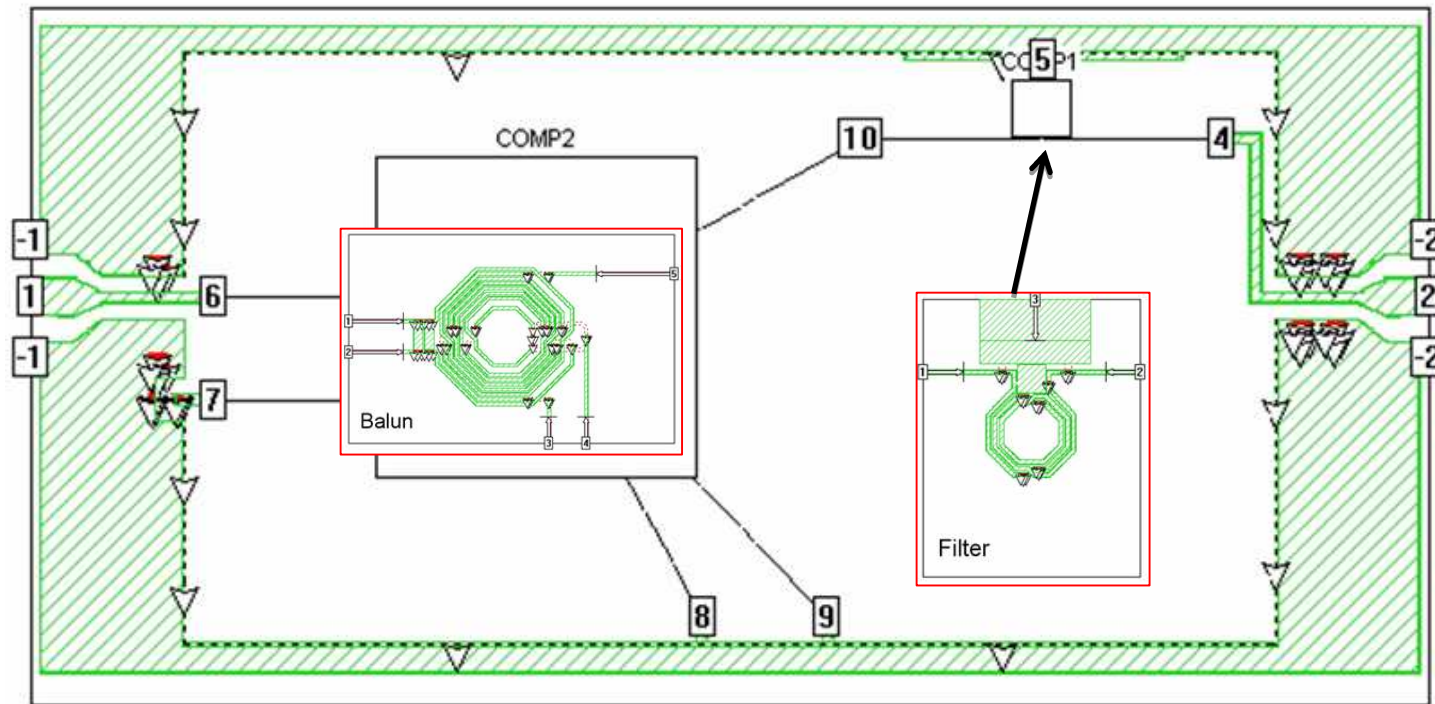
Multi-level Interconnects



Metal-Metal Layer Combining

More productive

- **Re-use:** Sonnet supports hierarchical building block approach where EM blocks can be connected accurately
- This takes advantage of Sonnet's unique CoCalibrated ports



The result that you need, in the format that you need

- S/Y/Z-Parameters in various formats
 - Plot results using built-in equations, e.g. extracted L/C/Q
 - MDIF format to export parameter sweep results
 - Broad band SPICE models in Cadence and PSpice format
 - Coupled transmission line data for Spectre "mtLine" element
 - New in v13: Lumped model extraction for inductors
-
- With Cadence and ADS integration, the proper symbols will be created automatically, for easy use of Sonnet simulation results

Cost Efficient License Model

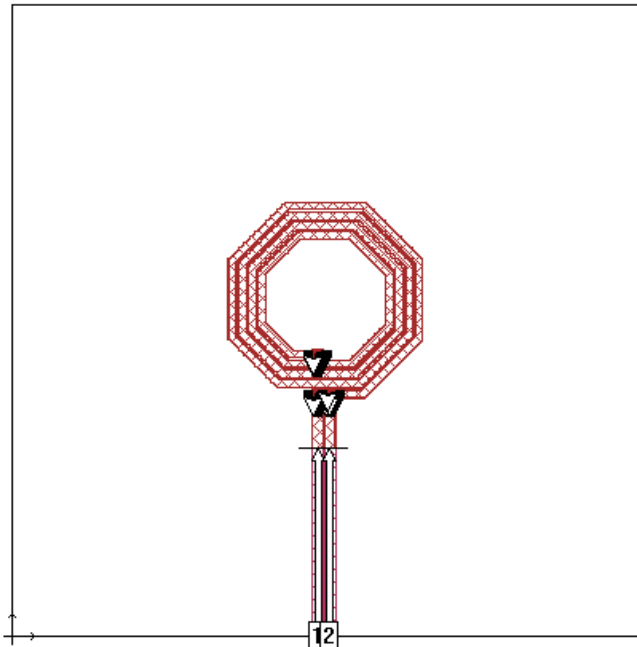
- Modular license model allows license time sharing:
Only those features are checked out which are actually in use
- Does not occupy an expensive framework license
- Cross-platform use is fully supported
- Simulation queue for solver
- Solver available in two versions: max. 3 cores and max. 12 cores
- LSF cluster simulation available
- Node locked or floating license (LAN)
- Continental WAN option for floating licenses (+30%)
- Global WAN option for floating licenses (+50%)

License Features

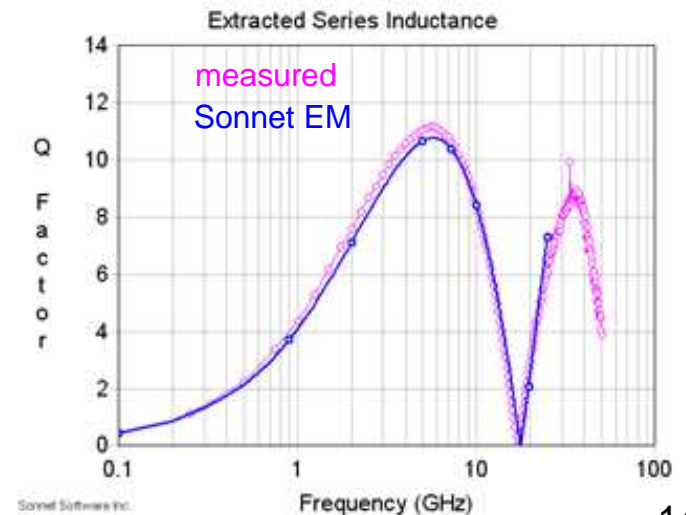
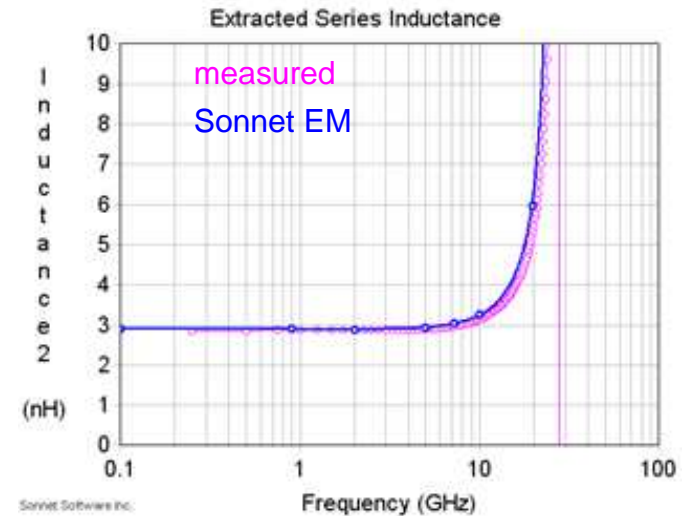
Sonnet Module	License feature
Project editor	xgeom
Desktop EM Solver (max. 3 Cores)	emdesktop
High Performance EM Solver (max. 12 Cores)	emhighperformance
Sonnet cluster computing (supports LSF)	emcluster
Cadence Virtuoso Integration	cvbridge
Agilent ADS Integration	ebridge
AWR Microwave Office integration	mwoint
Broad Band SPICE Extraction	bbextract
DXF import/export	dxs
GDSII import/export	gds
Gerber RS274X PCB data import (single layer)	gerbersingle
Gerber RS274X PCB data import (multi layer, job files)	gerbermulti
Current density viewer	emvu
Antenna pattern viewer	patvu

Application Examples

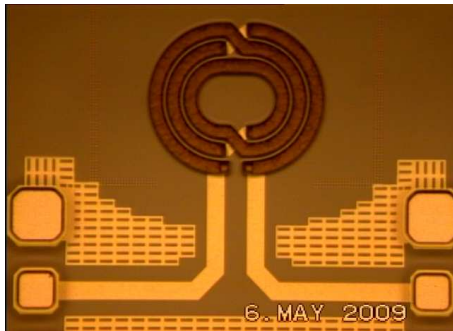
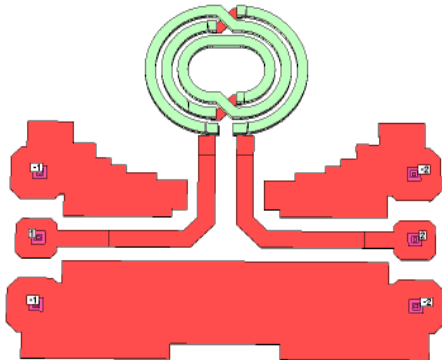
"Silicon Accurate" Results



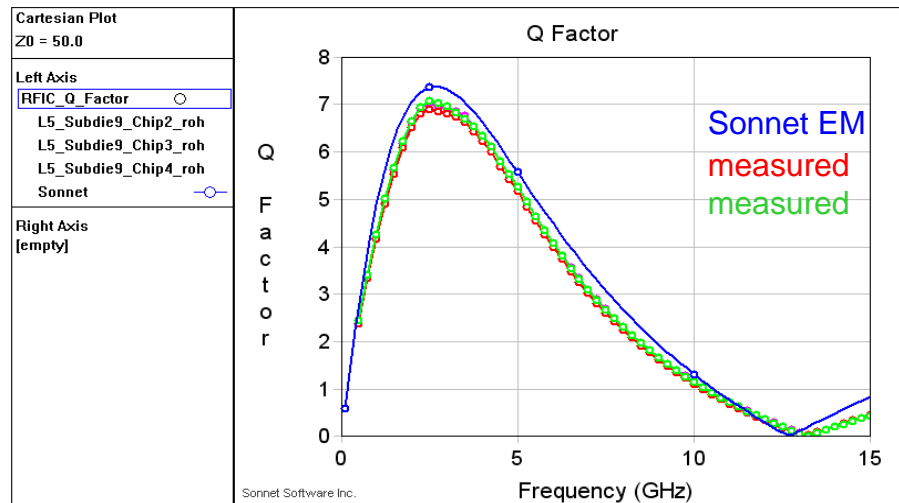
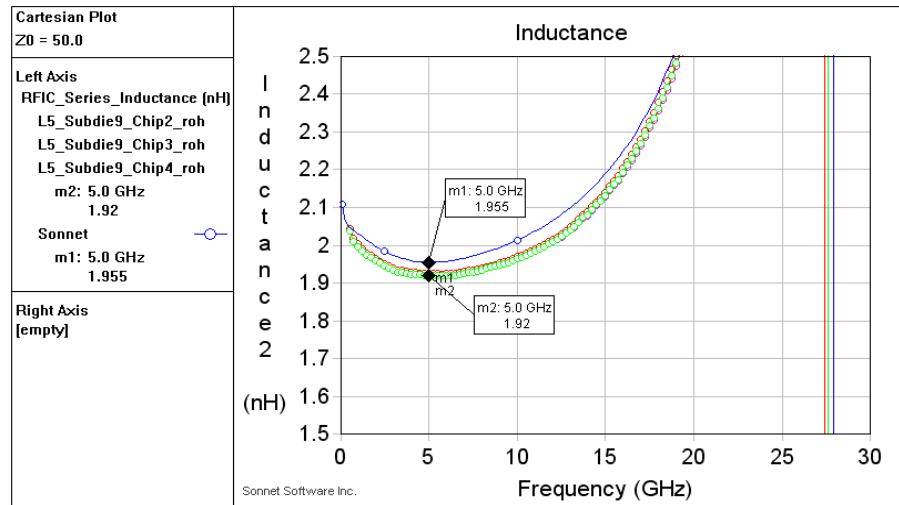
Courtesy of IHP GmbH



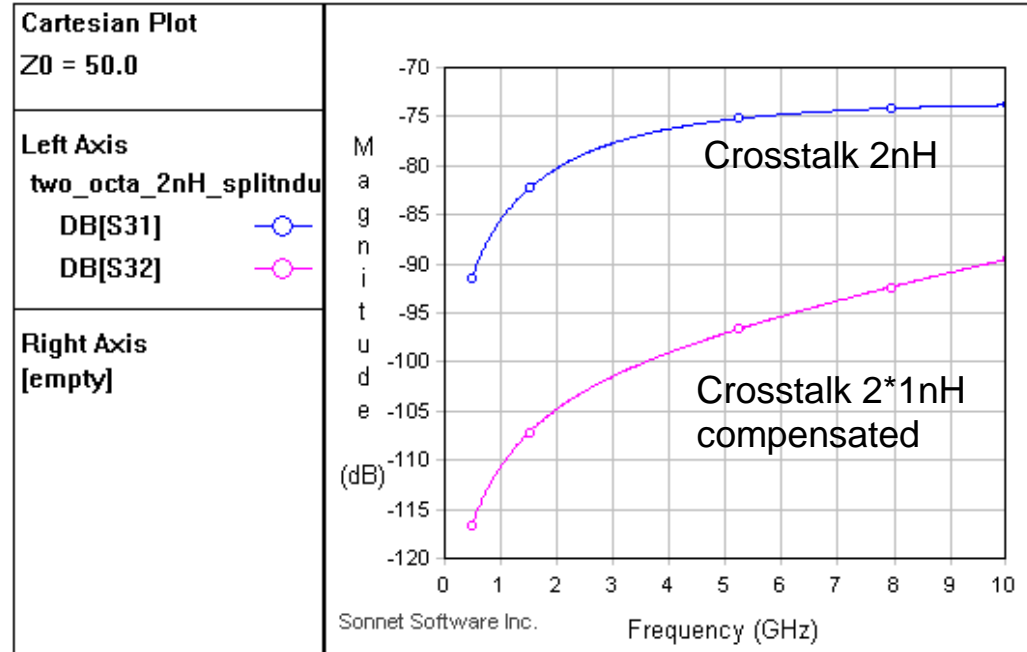
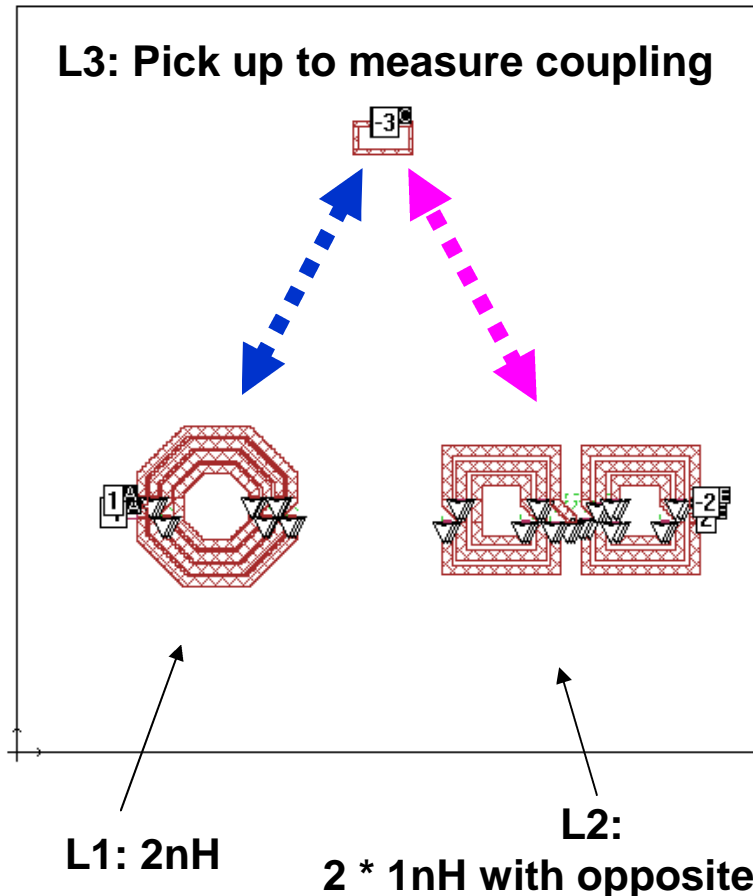
"Silicon Accurate" Results



Courtesy of
Landshut Silicon Foundry GmbH
Analog Alchemy GmbH

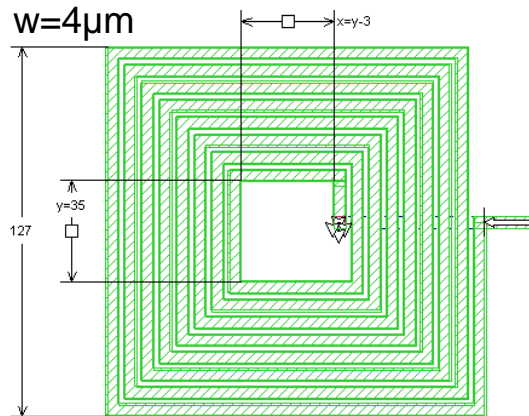


Inductor Coupling

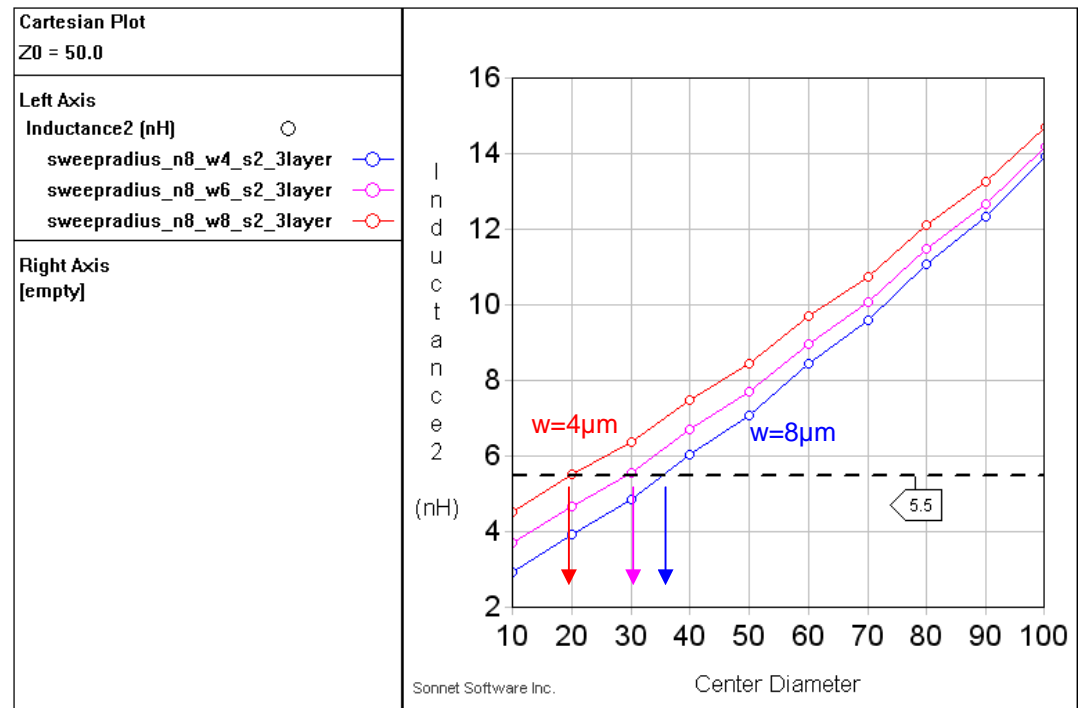
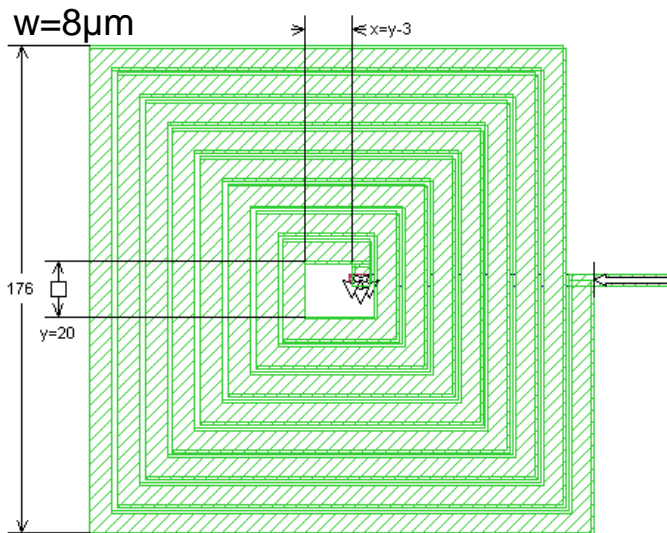


"Compensated" inductor reduces cross talk because far field cancels

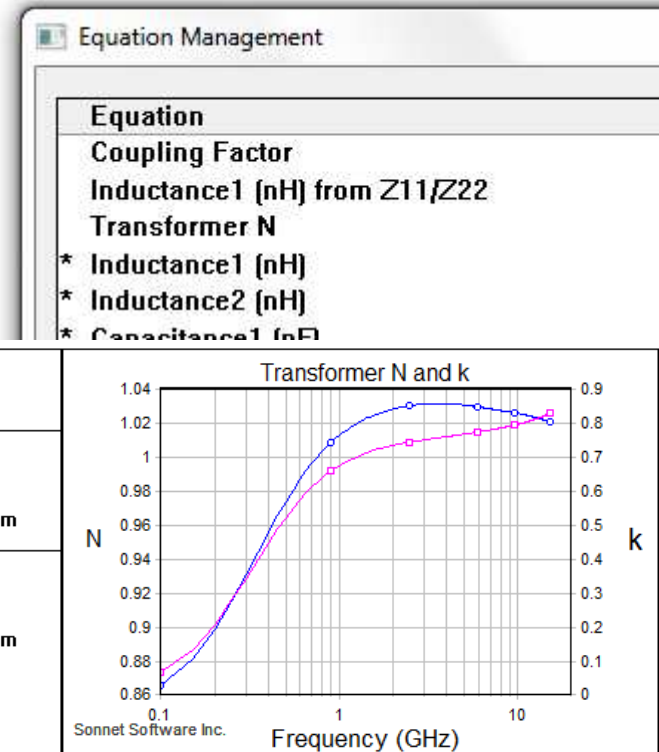
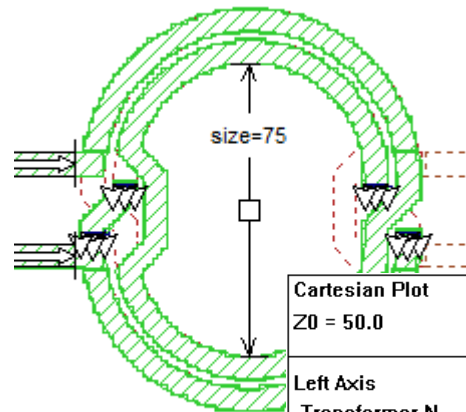
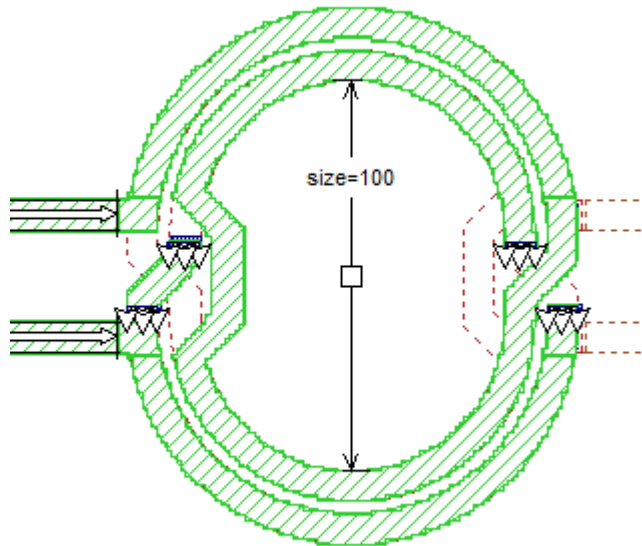
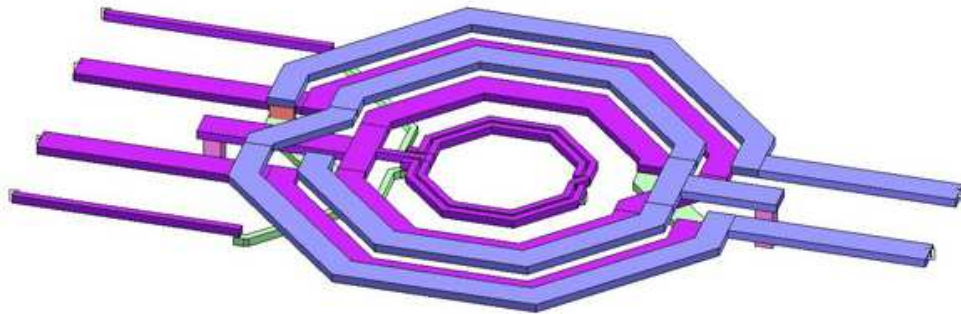
Geometry Parameter Sweep



Inductance vs. center diameter



Transformers



Training & Consulting

- Mühlhaus has 20 years RF EDA experience, 10+ years Sonnet experience and extensive experience with RFIC EM modelling and EM technology support for foundries
- We offer on-site training and software support
- Consulting: Sonnet design flow and EM methodology support
- Consulting: Set up and verify stackup data for RFIC technologies
- Consulting: Custom tools for Sonnet integration into your design flow
- Consulting: We assist you with EM modelling and analysis

Summary

- Reduced respins: Sonnet gives more "first time right" designs
- One for all: Sonnet fits into many different design flows, gives you the freedom of choice as your needs change
- Sonnet is easy to use, reduces risk of user mistakes
- Ready for the future: Sonnet is accurate for dense mixed technology layouts with closely spaced ports, due to superior port calibration
- The power that you need: EM solver speed is scalable when your projects get more complex, without sacrificing accuracy
- Cost effective license model
- Experienced support and consulting by Mühlhaus