

An Introduction to Sonnet

Dr. José Ernesto Rayas Sánchez

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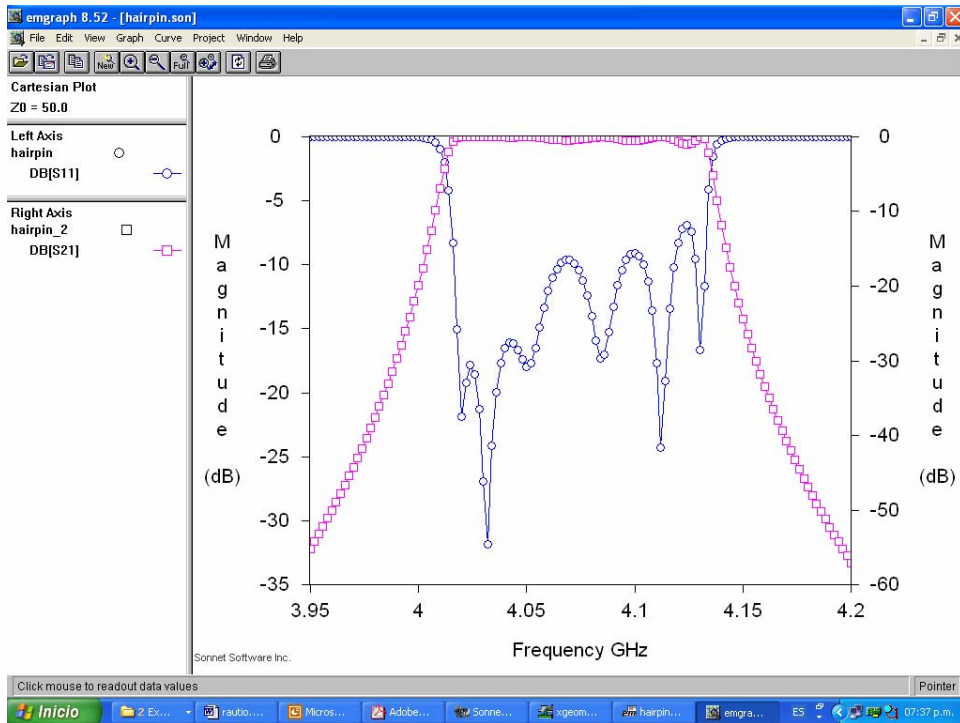
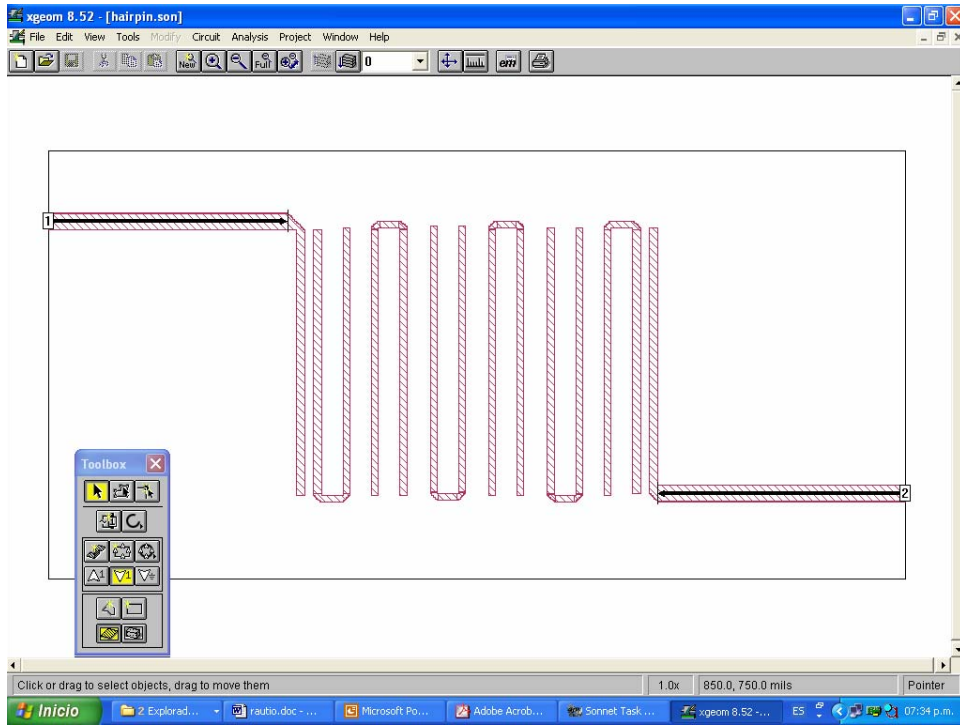
Sonnet EM Simulator

- A 3-D planar EM analysis software
- Based on the Method of Moments
- Intended for frequency-domain analysis of planar circuits (microstrip, stripline, PCBs, and integrated circuits)
- Not intended for completely arbitrary 3-D problems
- Development started in 1983 by Dr. James C. Rautio
- Commercial introduction in 1989

www.sonnetusa.com

Signal Integrity and High-Speed Interconnects

January-May 2006



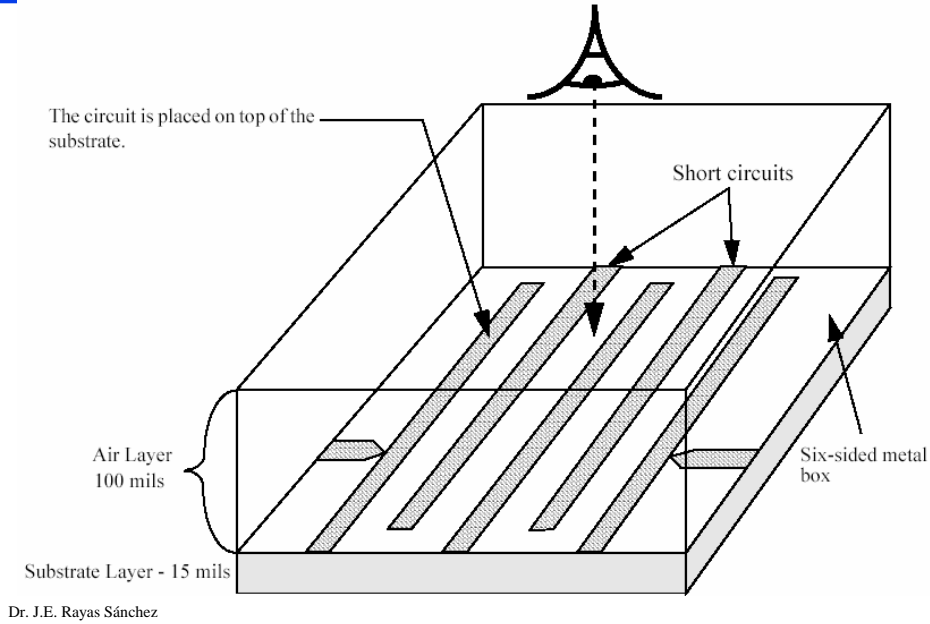
Basic Sonnet Tools

- ‘xgeom’, for drawing the circuit to be analyzed
- ‘em control’ to launch an analysis with the ‘em’ analysis engine
- ‘emgraph’ to plot the results
- ‘emvu’ to view and animate current distributions in both frequency domain and time domain (for a given exciting frequency)

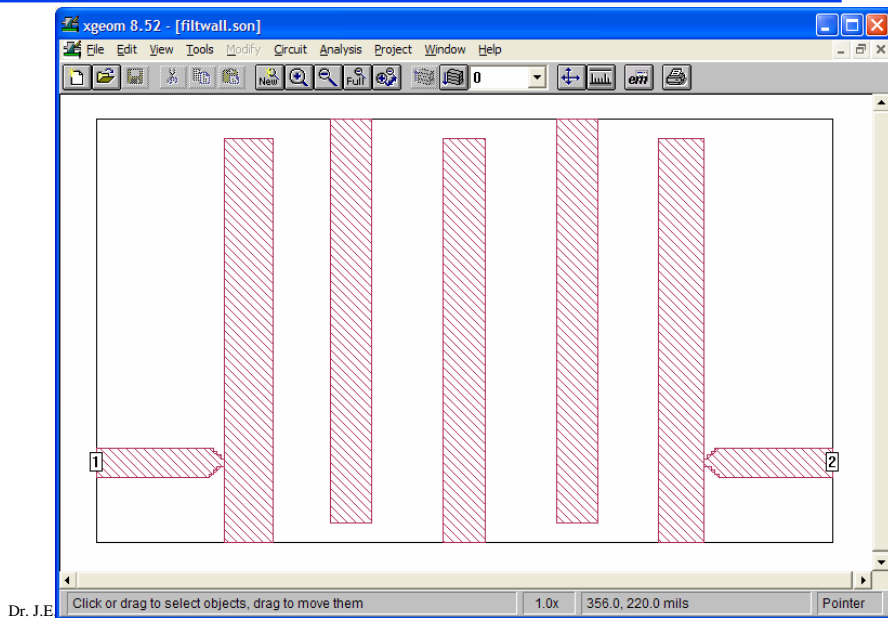
Decomposition Capabilities

- ‘em’ includes a net-list based circuit theory analysis that allows complete EM simulations to be included in the net-list
- Very useful for breaking a circuit into pieces, having each piece automatically analyzed and then all results automatically connected back together

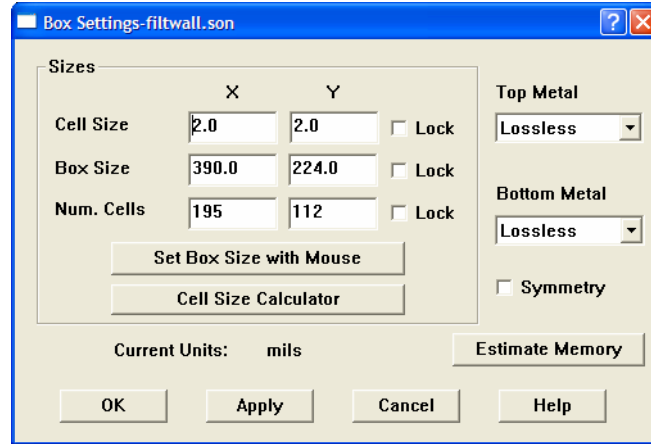
The Project Editor – Example 1



The Project Editor – Example 1 (cont)



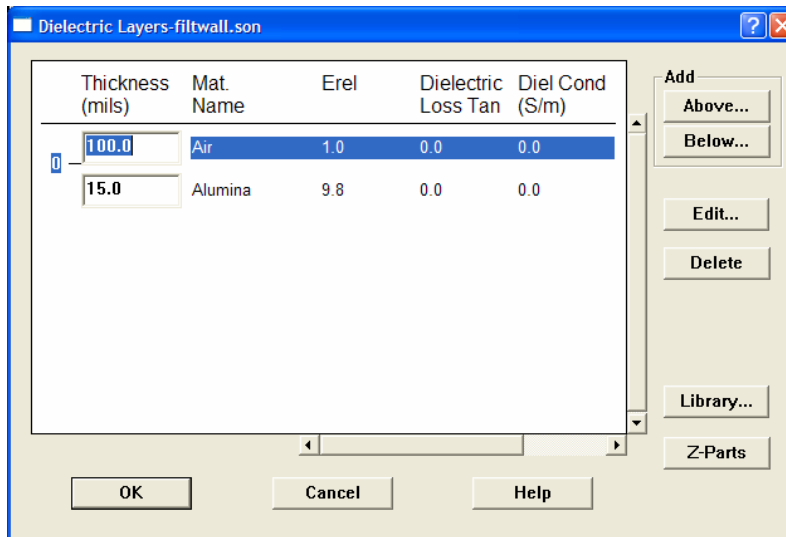
The Project Editor – Example 1 (cont)



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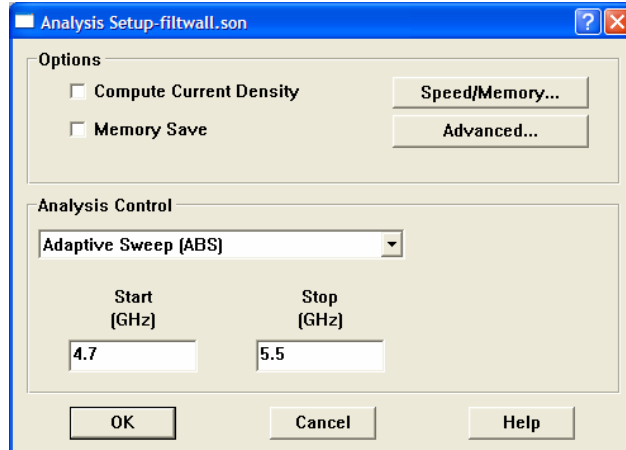
The Project Editor – Example 1 (cont)



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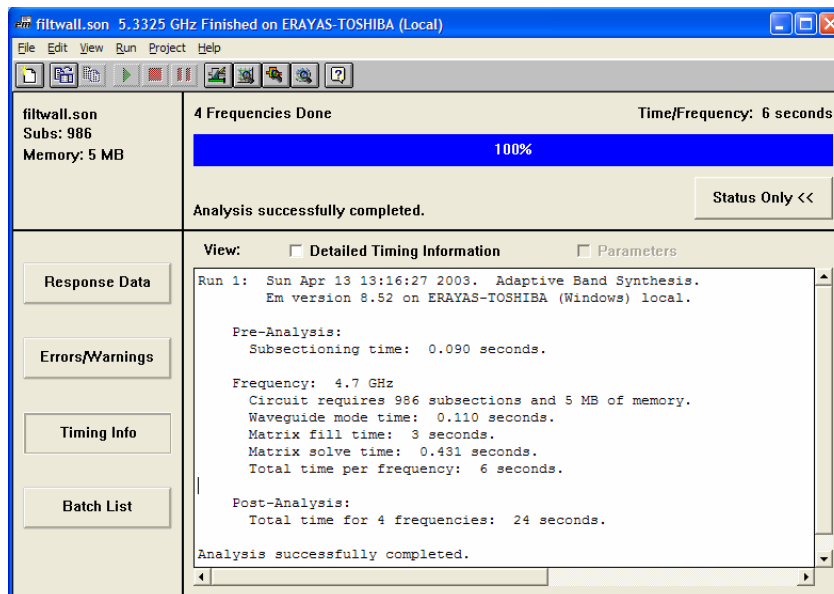
Setting-up the Analysis – Example 1



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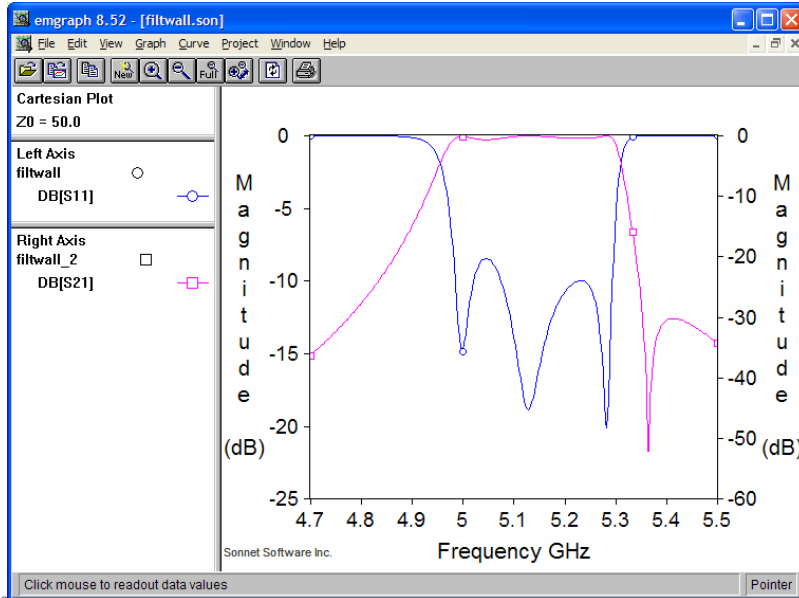
Running the Simulation – Example 1



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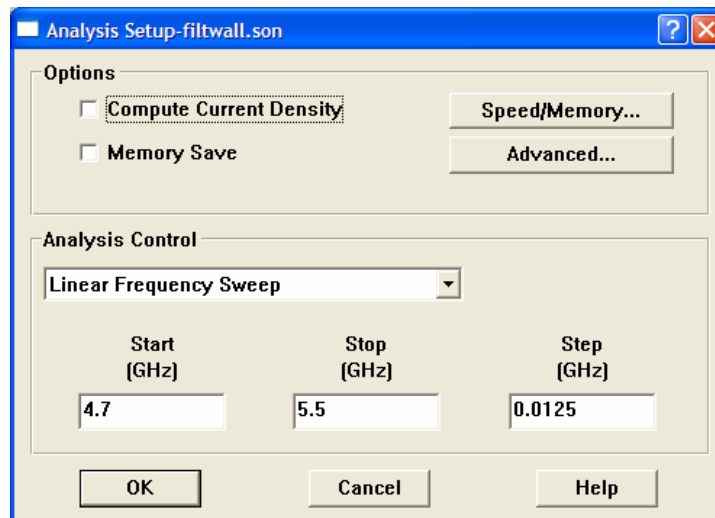
Showing Results – Example 1



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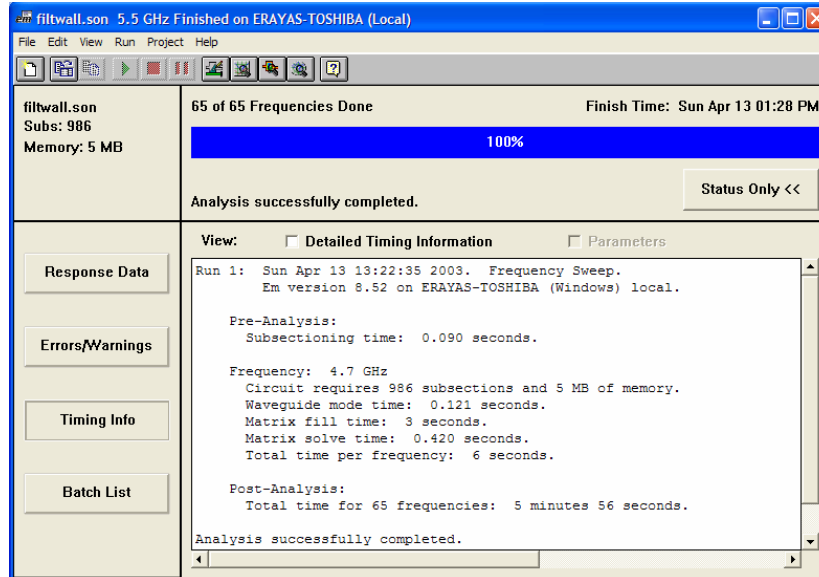
Setting-up the Analysis – Example 1 (cont)



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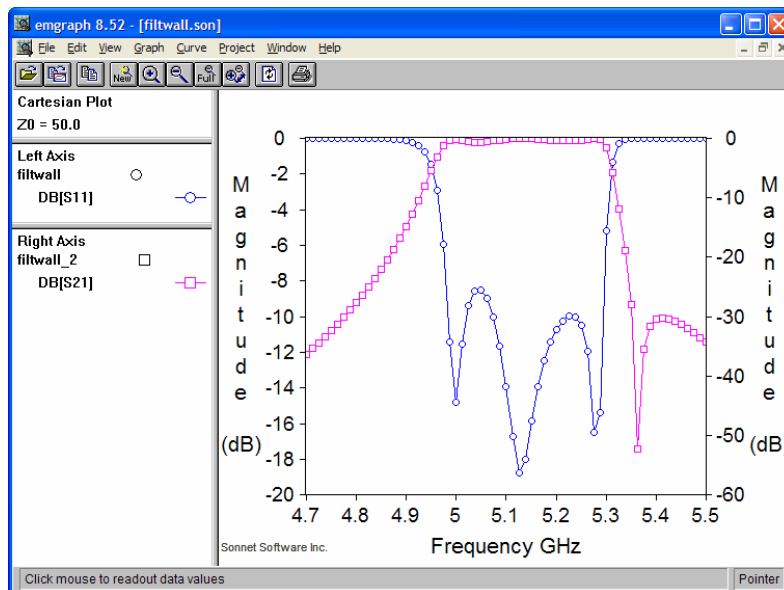
Running the Simulator – Example 1 (cont)



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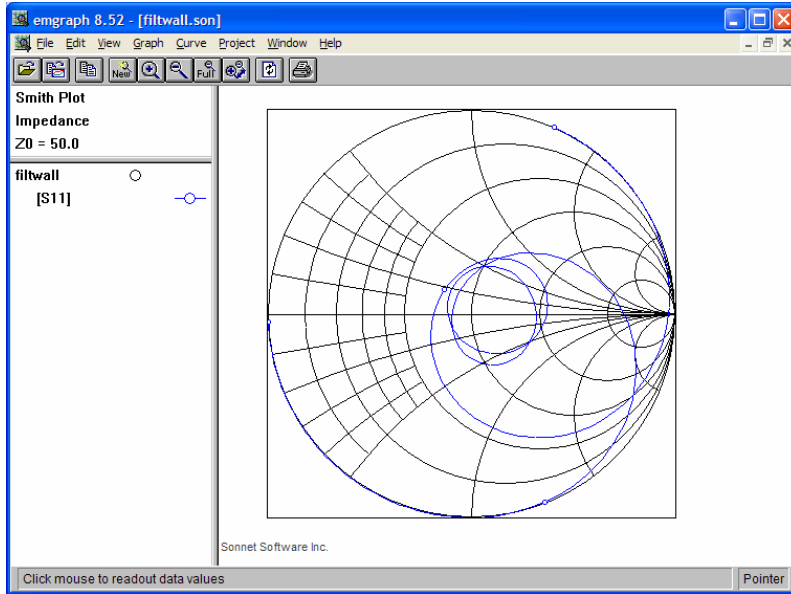
Showing Results – Example 1 (cont)



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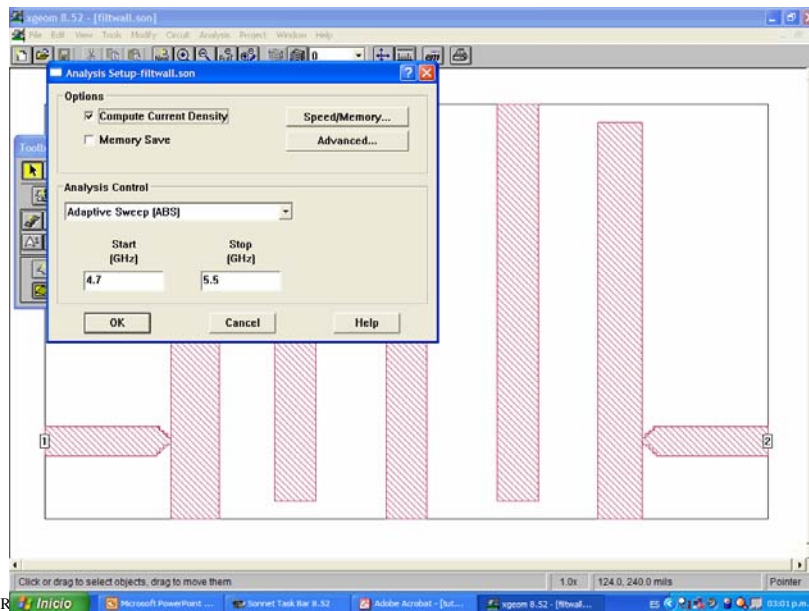
Showing Results – Example 1 (cont)



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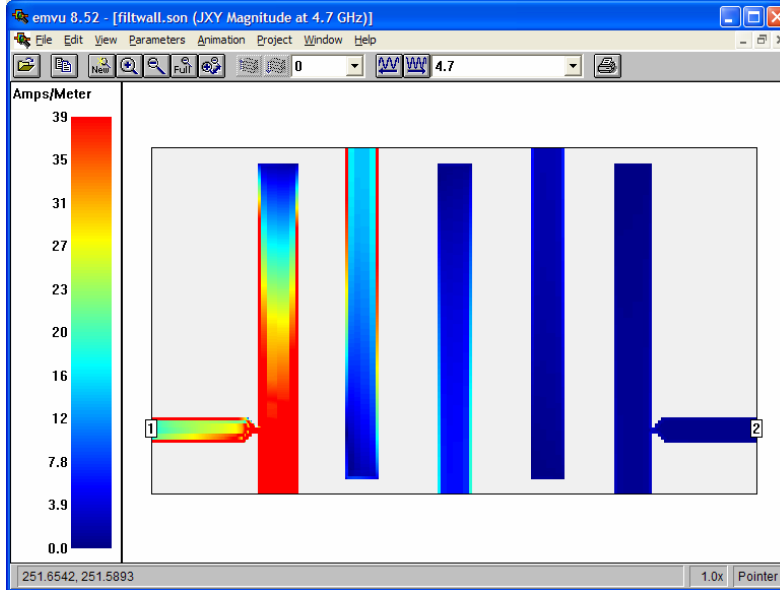
Current Density Viewer – Example 1 (cont)



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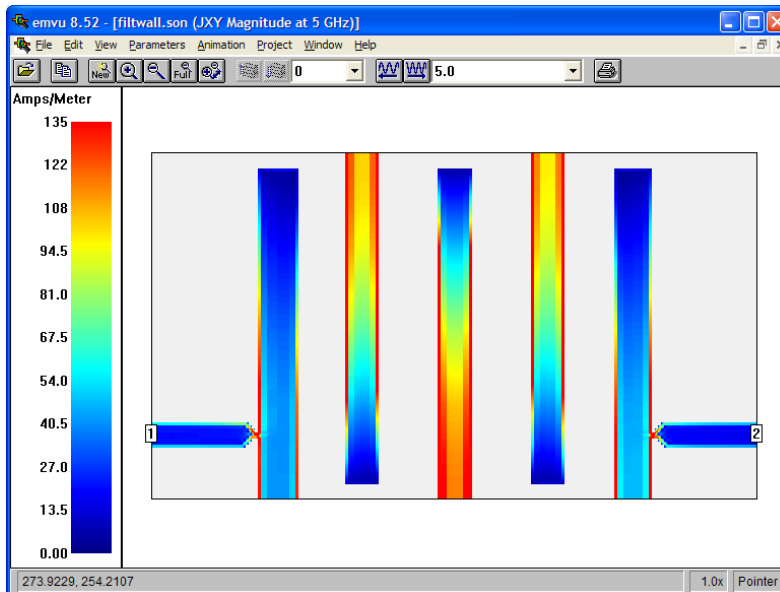
Current Density Viewer – Example 1 (cont)



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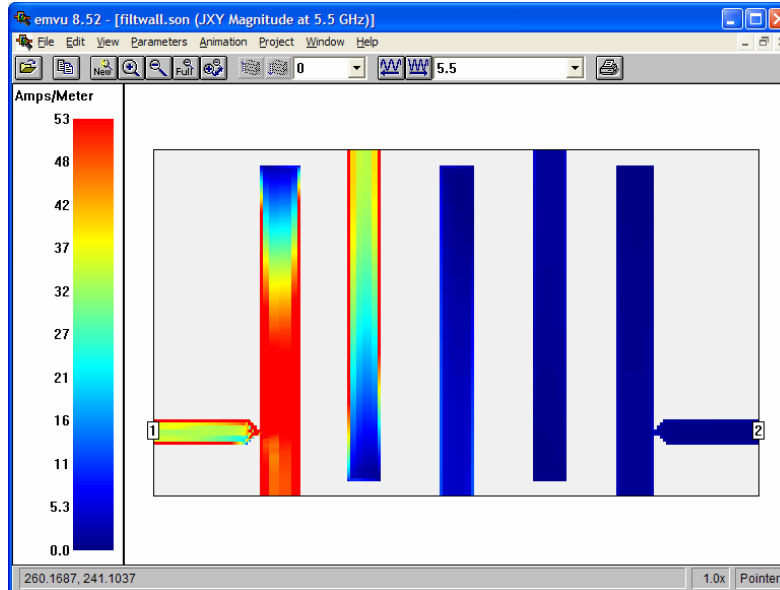
Current Density Viewer – Example 1 (cont)



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Current Density Viewer – Example 1 (cont)



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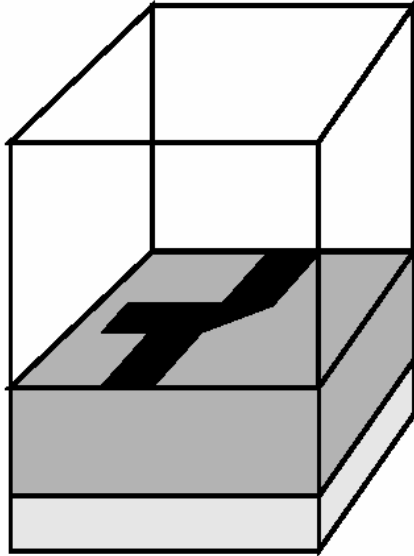
The Substrate, Subsectioning, and Cell Size

- Sonnet encloses the circuit in a metal box
- The substrate covers the bottom area of the box
- Cell Size, Box Size and Number of Cells in each direction (x or y) are related as
$$\text{Cell Size} \times \text{Number of Cells} = \text{Box Size}$$
- The EM analysis starts by automatically subdividing the circuit into small rectangular subsections
- Sonnet uses variable size subsections (small subsections are used where needed)
- A Cell is the building block for all subsections, and each subsection is built from one or more cells
- To reduce memory requirements use a cell size as large as possible

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The Box and the Substrate

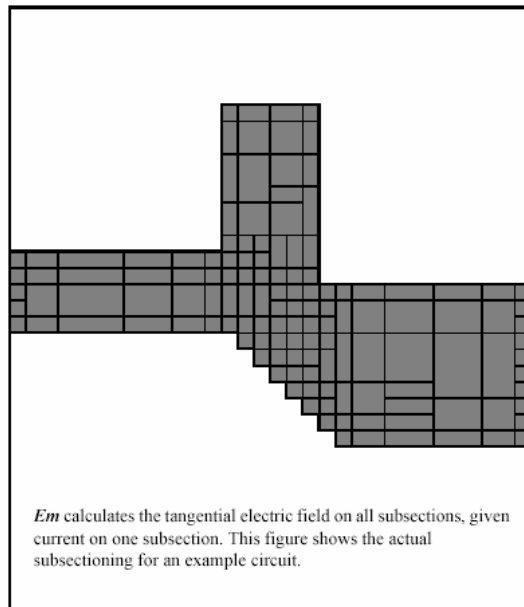


Em analyzes planar structures inside a shielding box. Port connections are usually made at the box sidewalls. Vias and dielectric bricks (not shown) may also be included.

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Subsectioning

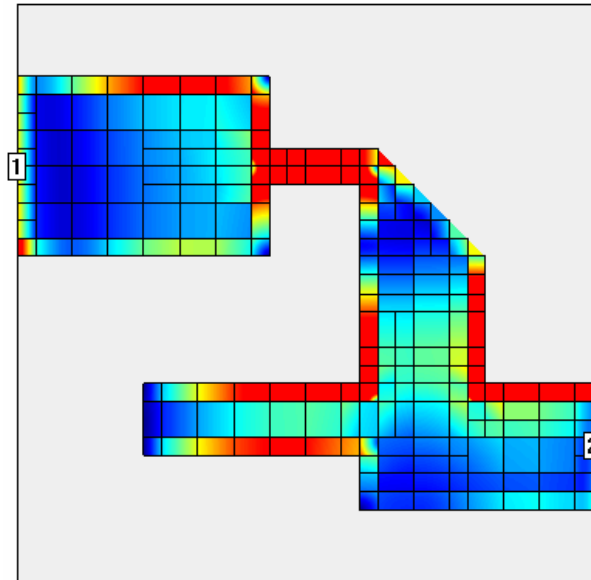


Em calculates the tangential electric field on all subsections, given current on one subsection. This figure shows the actual subsectioning for an example circuit.

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Subsectioning (cont)



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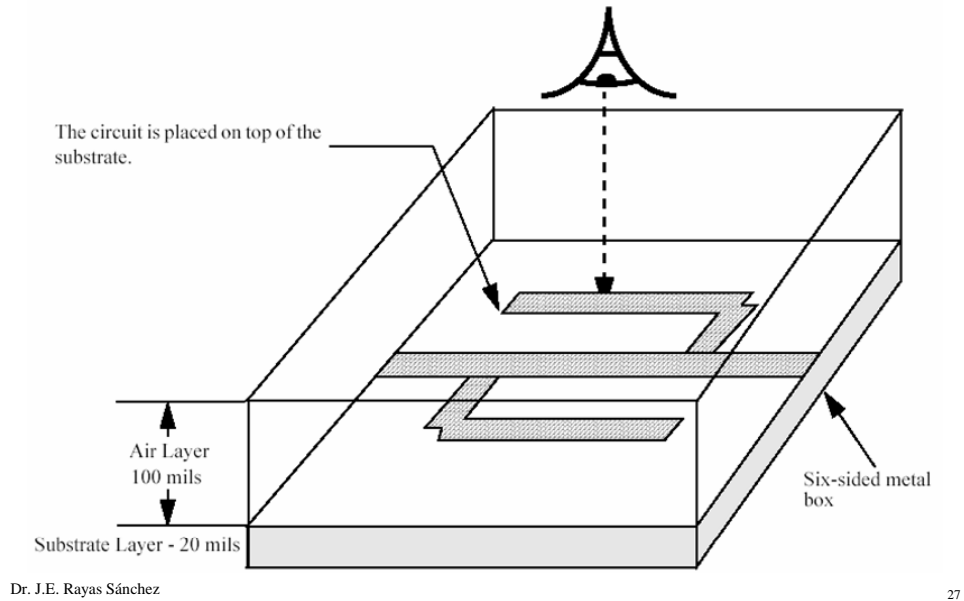
Metalization Levels and Dielectric Layers

- Sonnet Professional can handle any number of metalization levels
- Metalization is referred to as “levels” and dielectric as “layers”
- Each metalization level is sandwiched between two dielectric layers

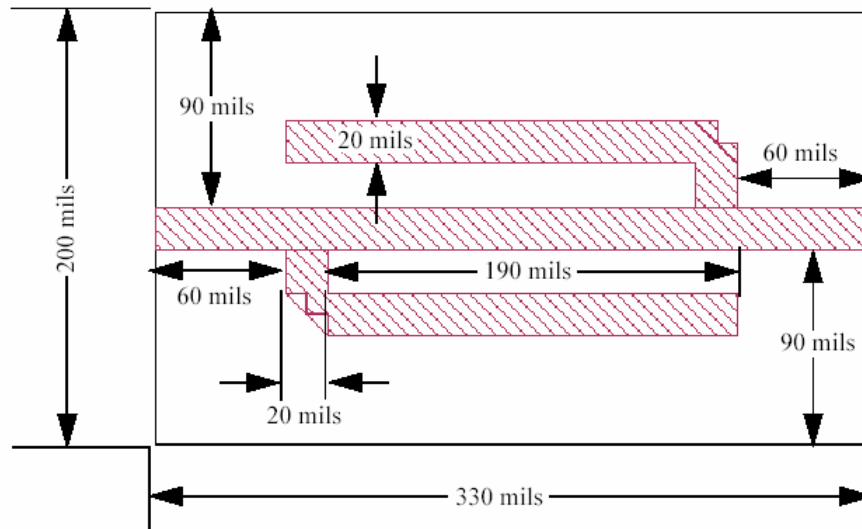
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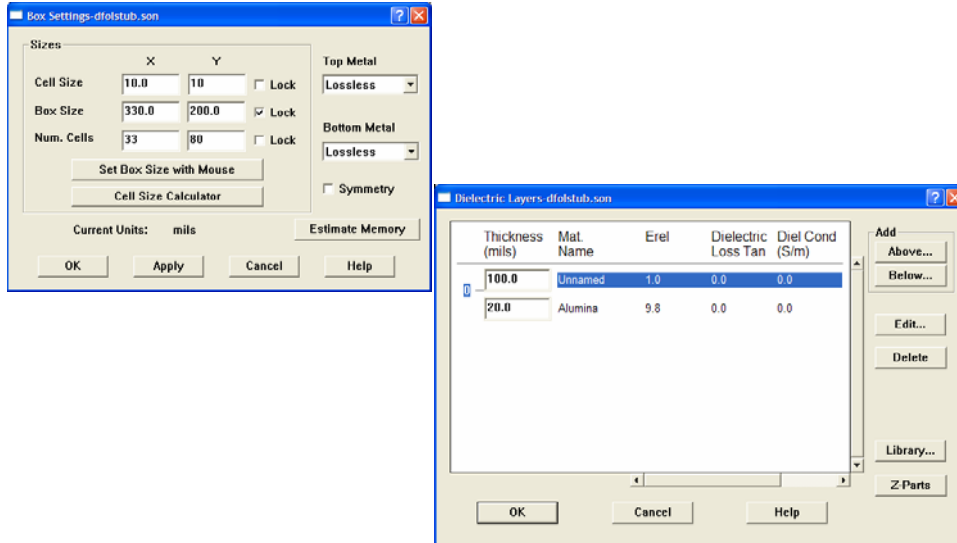
Example 2: A Double Folded Stub Filter



Example 2: A Double Folded Stub Filter (cont)



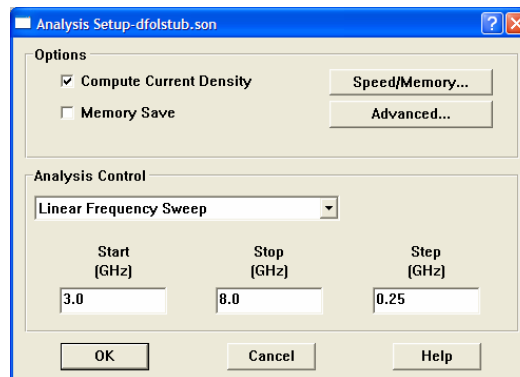
Setting up the Structure – Example 2



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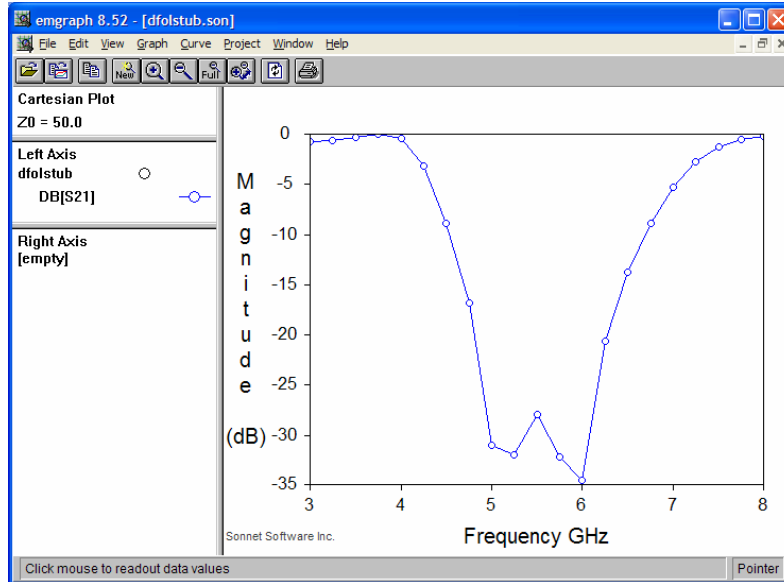
Setting up the Analysis – Example 2



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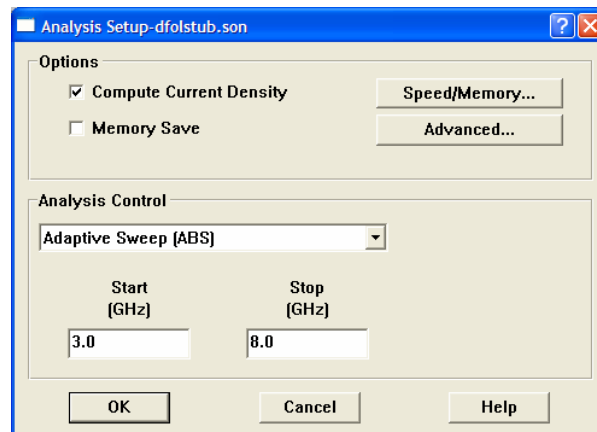
Results – Example 2



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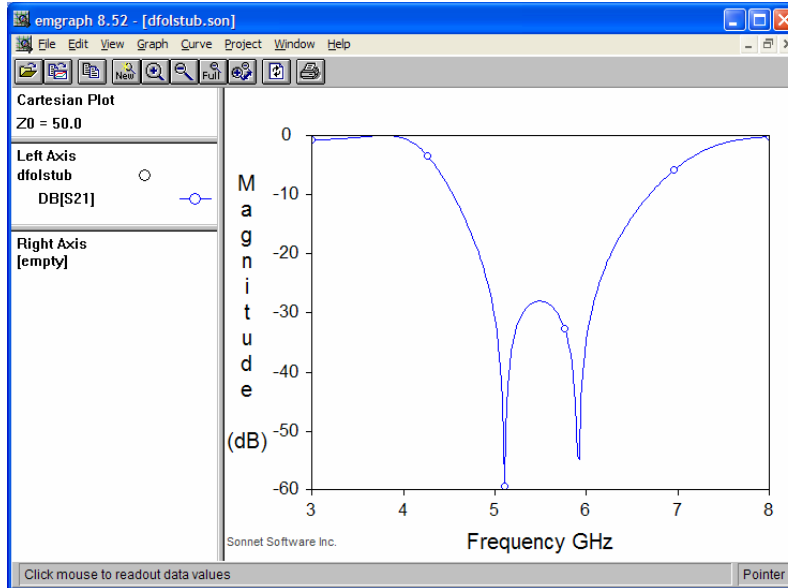
Using Adaptive Frequency Sweep – Example 2



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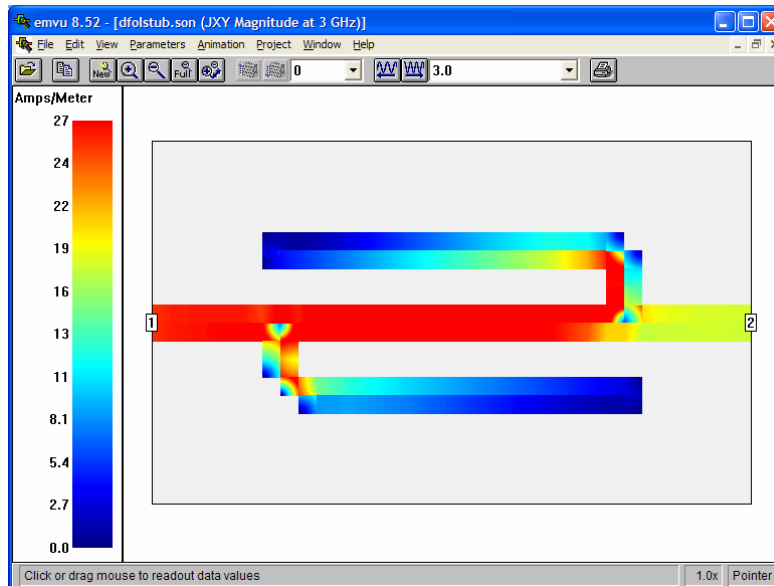
Results – Example 2



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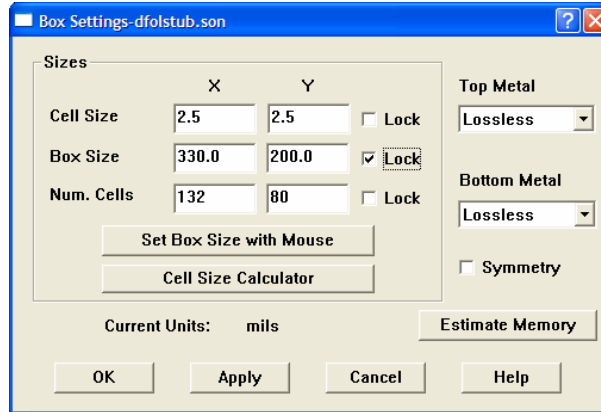
Results – Example 2



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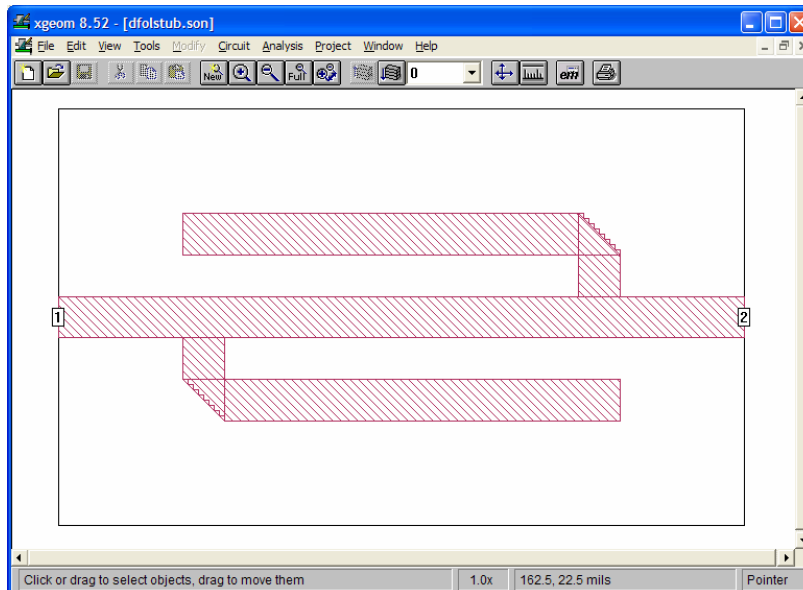
Increasing Resolution – Example 2



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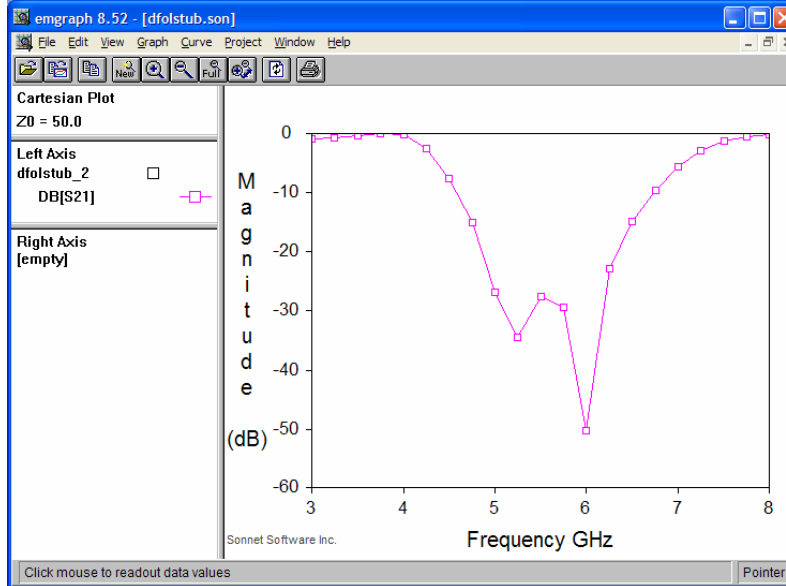
Increasing Resolution – Example 2 (cont)



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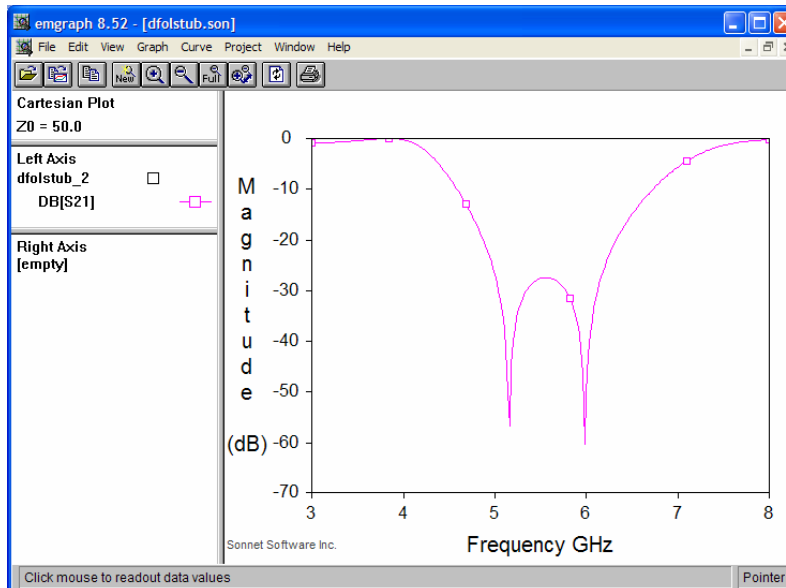
Increasing Resolution – Example 2 (cont)



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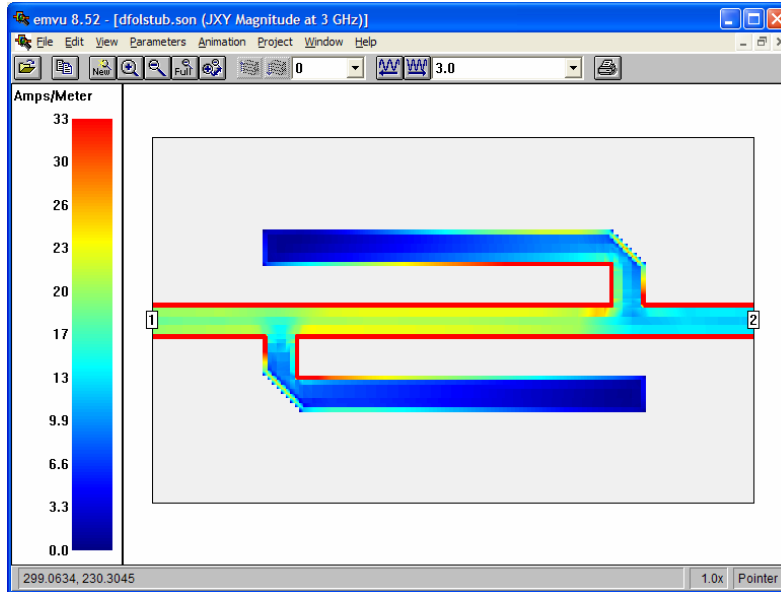
Increasing Resolution – Example 2 (cont)



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Increasing Resolution – Example 2 (cont)



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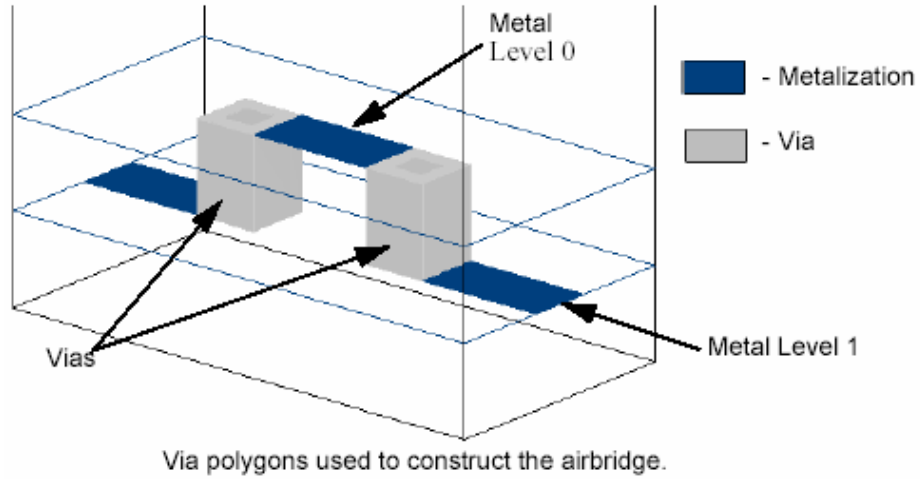
Vias

- A special kind of subsection which allows current to flow in the z-direction between metals
- “Ground via” connect metal on the surface of the substrate to the groundplane beneath the substrate
- “Level-to-level via” connect metalization between any two adjacent levels
- The length of the via is one cell size

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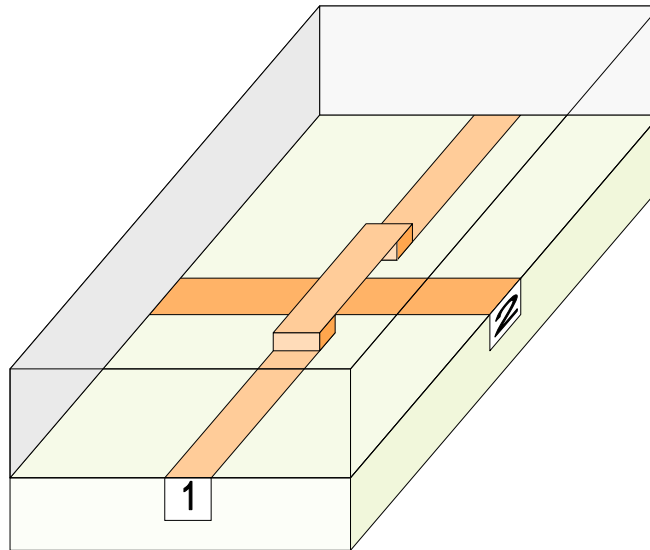
Vias (cont)



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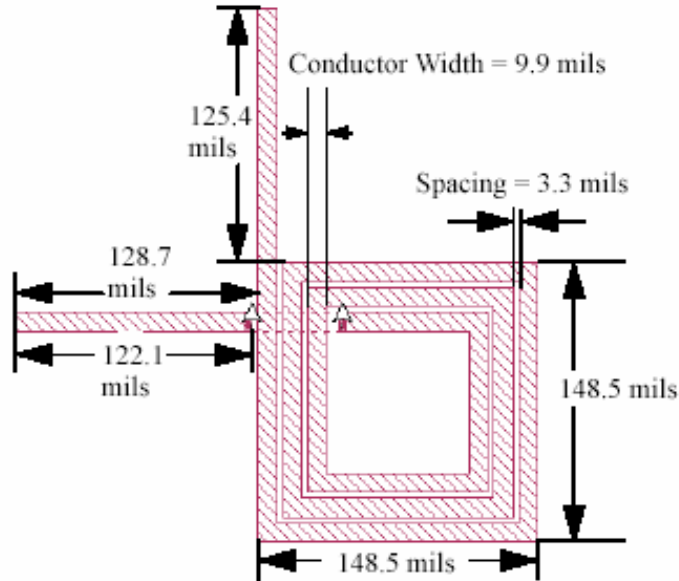
An Air Bridge



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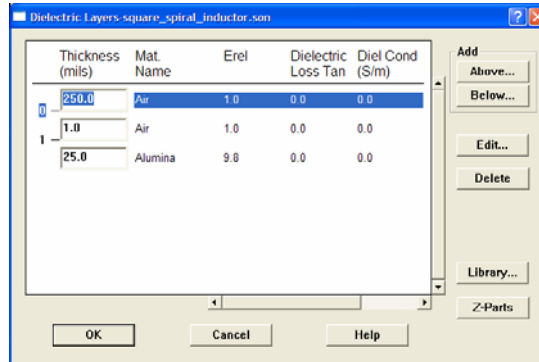
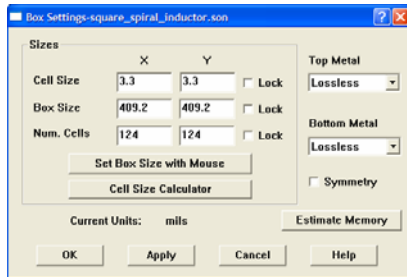
Example 3: Square Spiral Inductor



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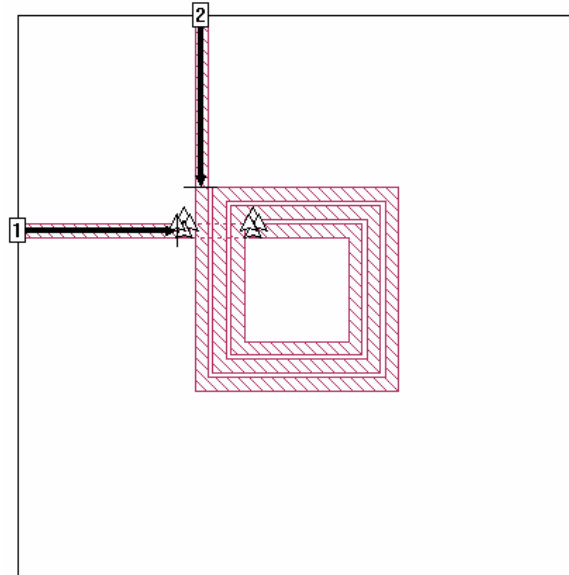
Setting Up the Structure – Example 3



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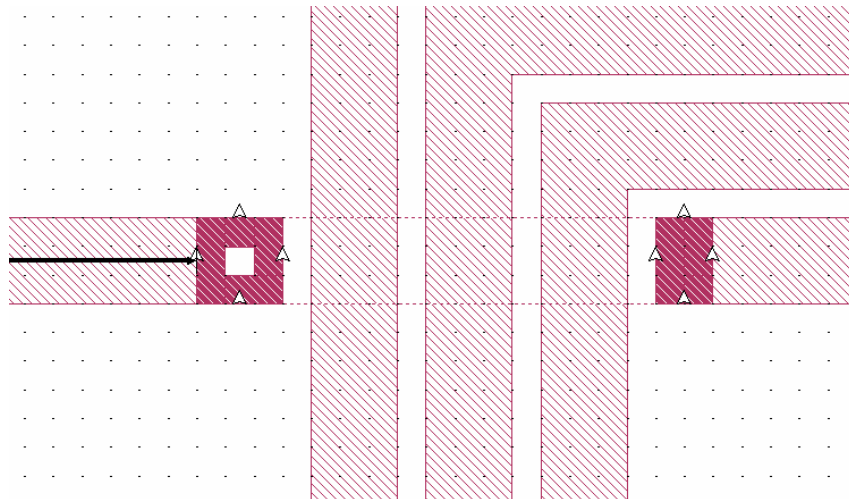
Square Spiral Inductor – Example 3



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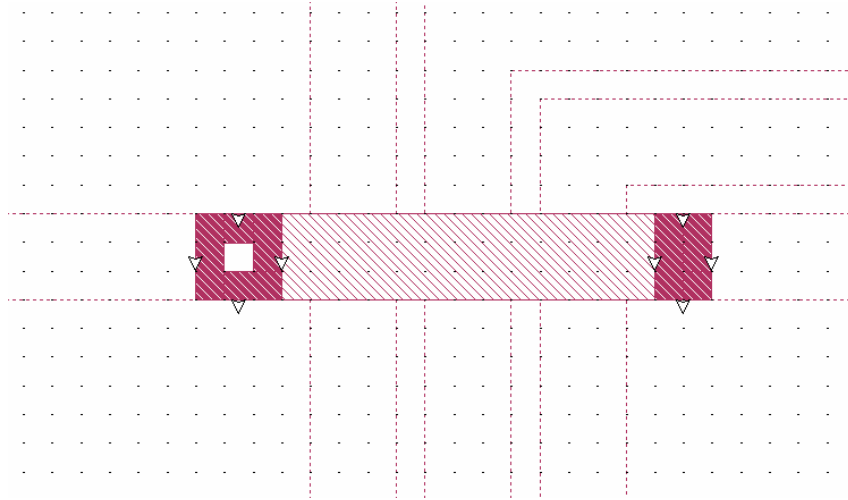
Vias (Lower Level) – Example 3



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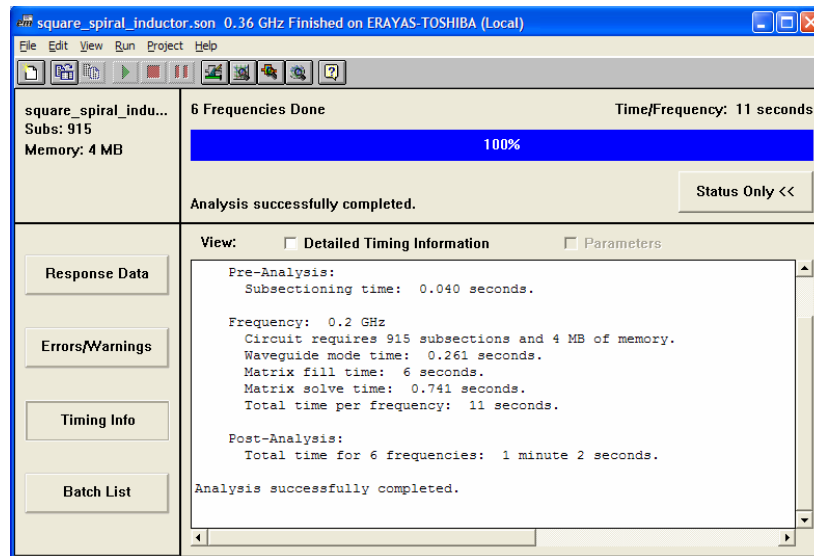
Vias (Upper Level) – Example 3



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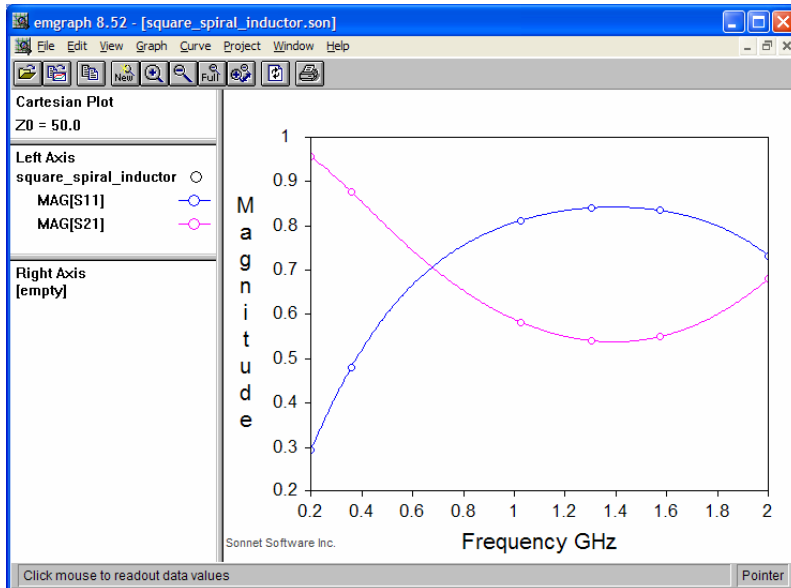
Simulation Time – Example 3



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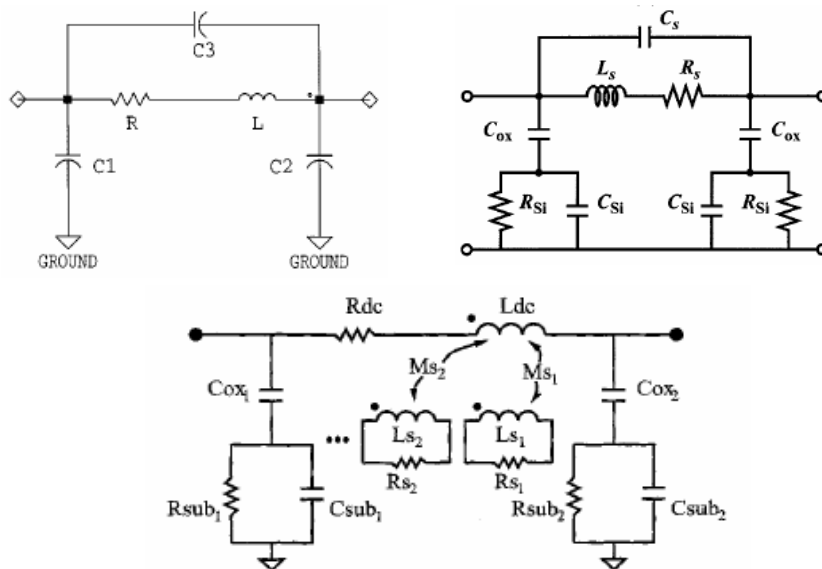
Results – Example 3



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Lumped Circuit Models for Spiral Inductors

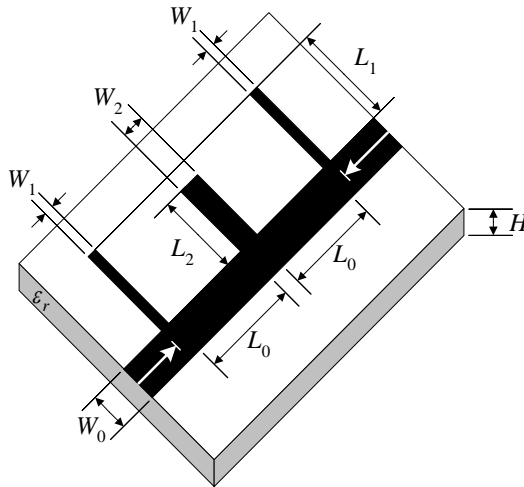


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Example 4

Bandstop Microstrip Filter with Quarter-Wave Open Stubs

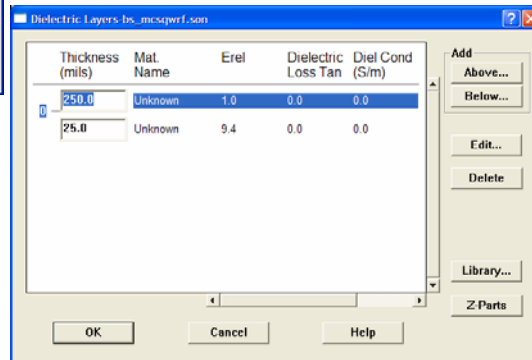
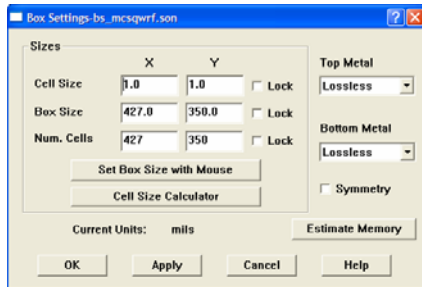


$H = 25$ mil
 $\epsilon_r = 9.4$ (alumina)
 $W_0 = 25$ mil
 $W_1 = 9$ mil
 $W_2 = 19$ mil
 $L_0 = 95$ mil
 $L_1 = 115$ mil
 $L_2 = 114$ mil

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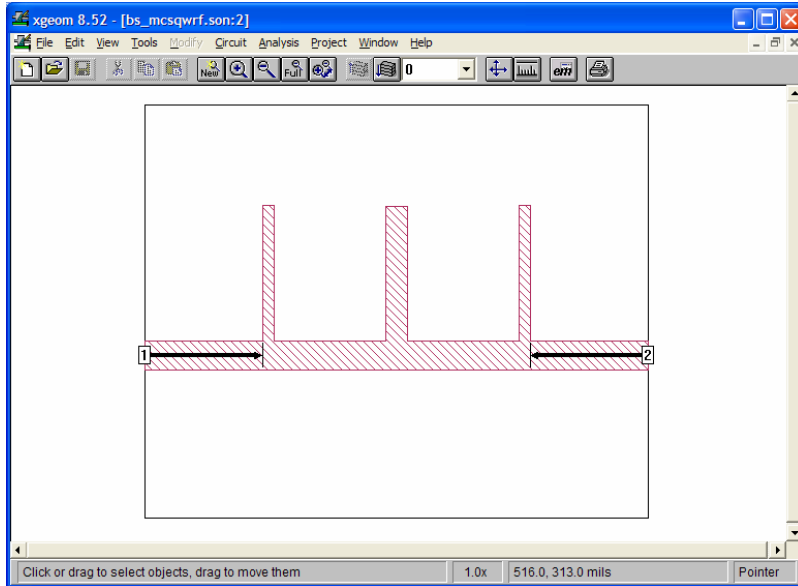
Setting-up Structure – Example 4



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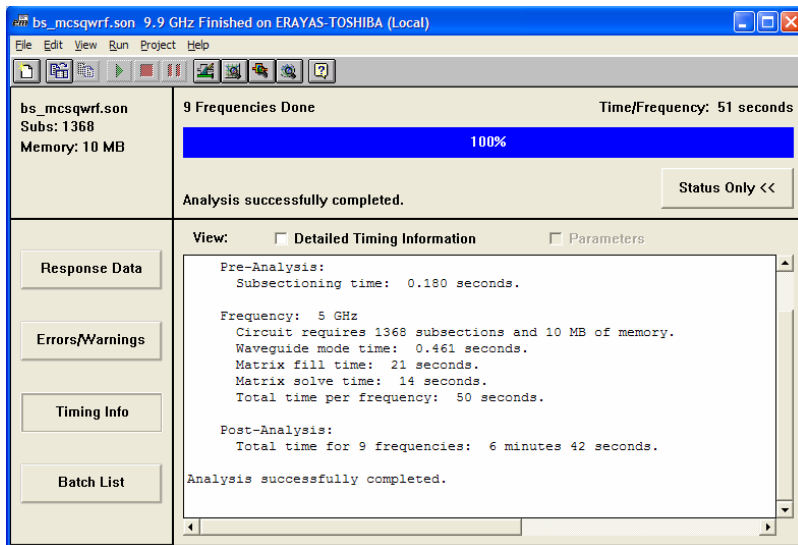
Structure – Example 4



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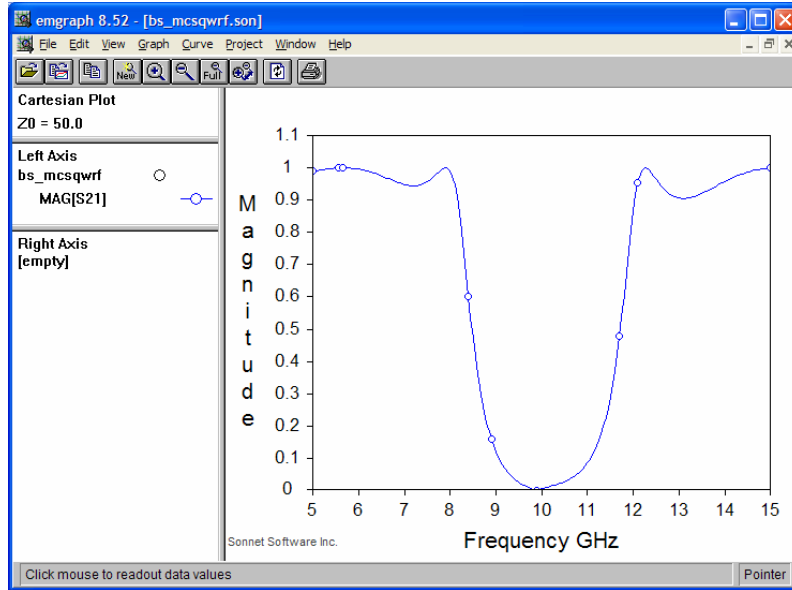
Simulation Time – Example 4



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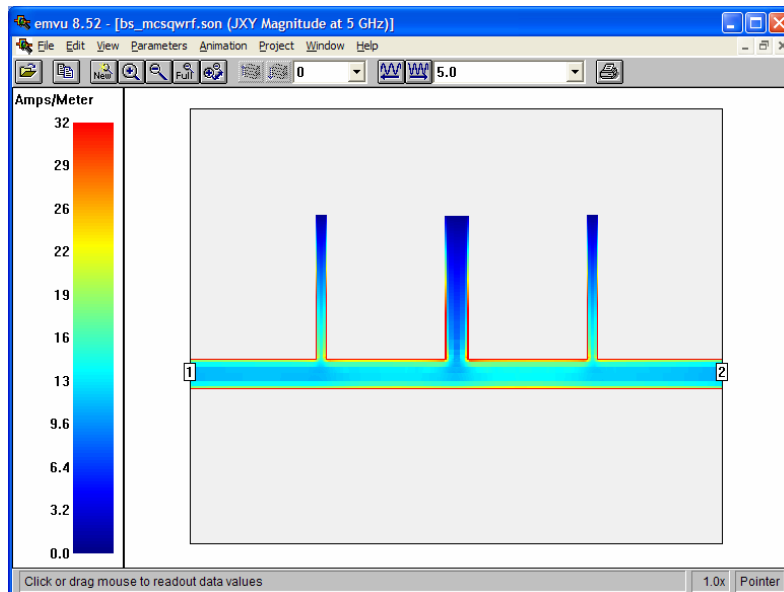
Results – Example 4



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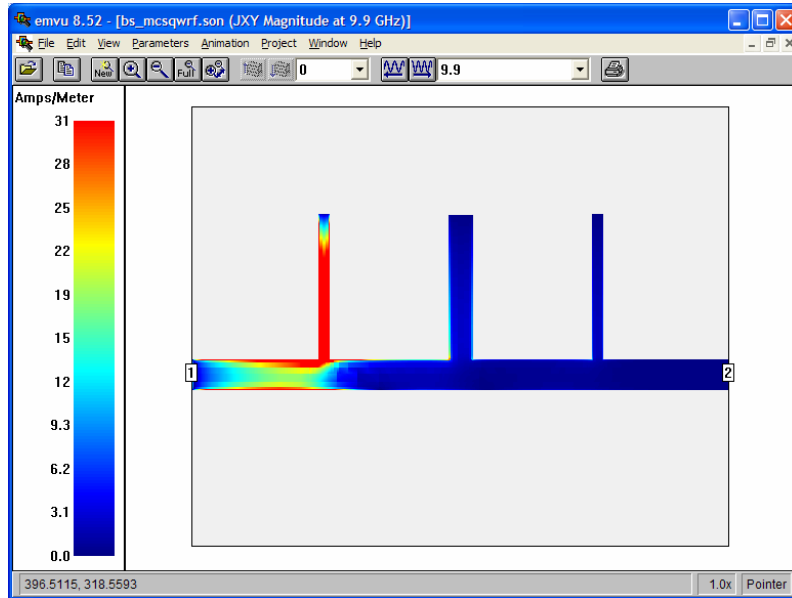
Current Density – Example 4



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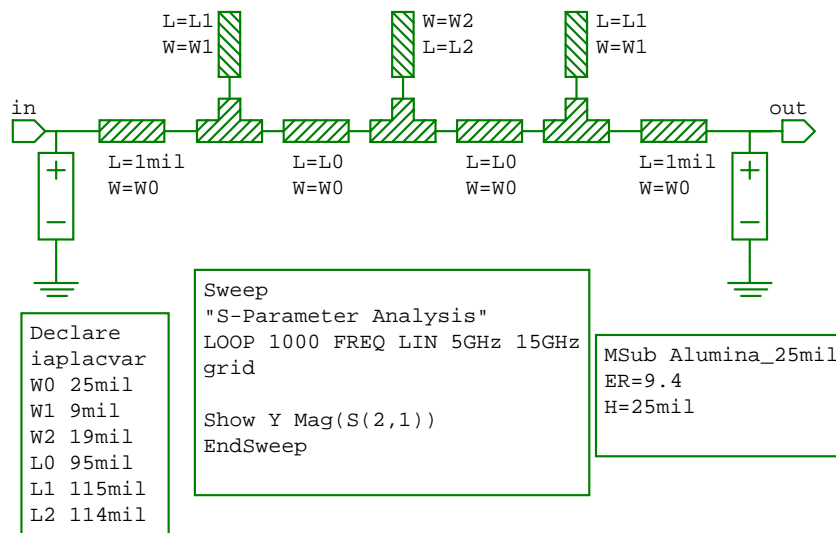
Current Density – Example 4 (cont)



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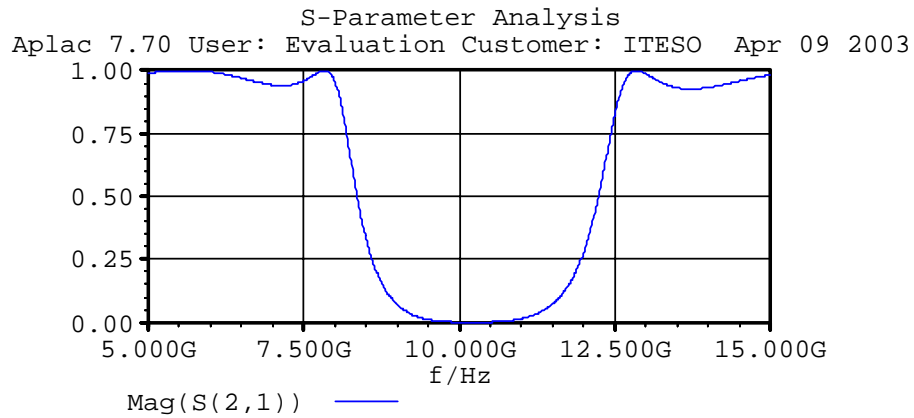
Aplac Model – Example 4



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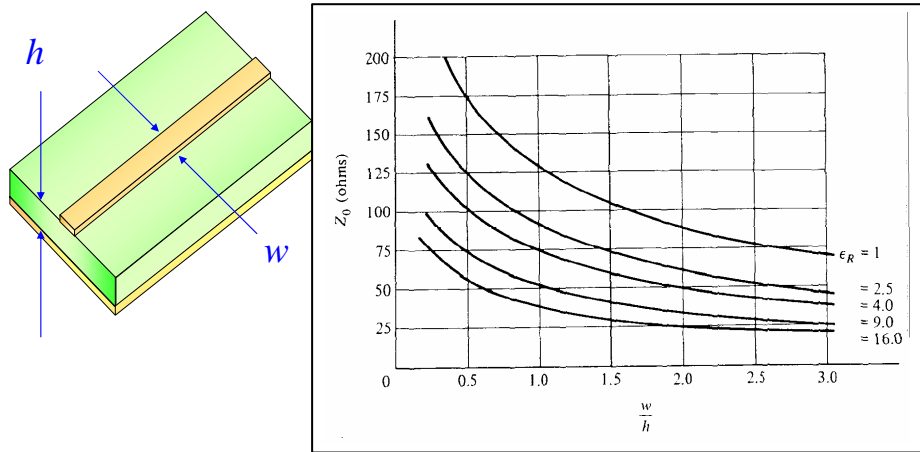
Results using Aplanac – Example 4



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Example 5: A Simple Microstrip Line



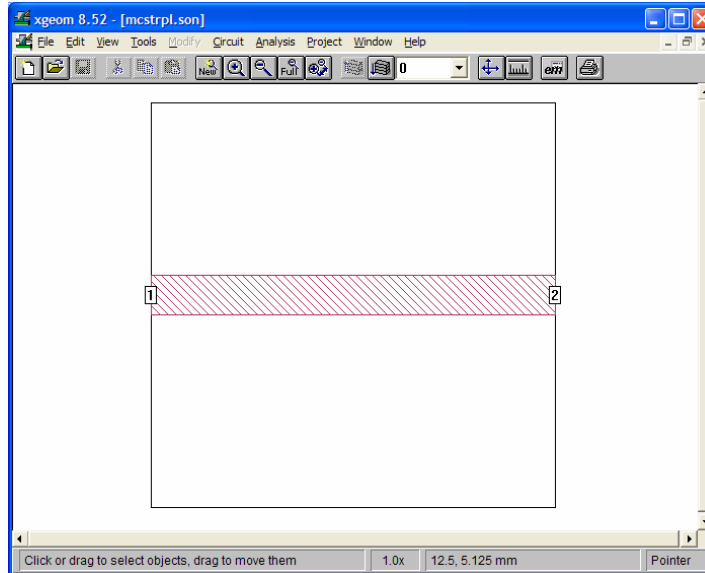
Characteristic impedance for microstrip transmission lines

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(assumes nonmagnetic dielectric)

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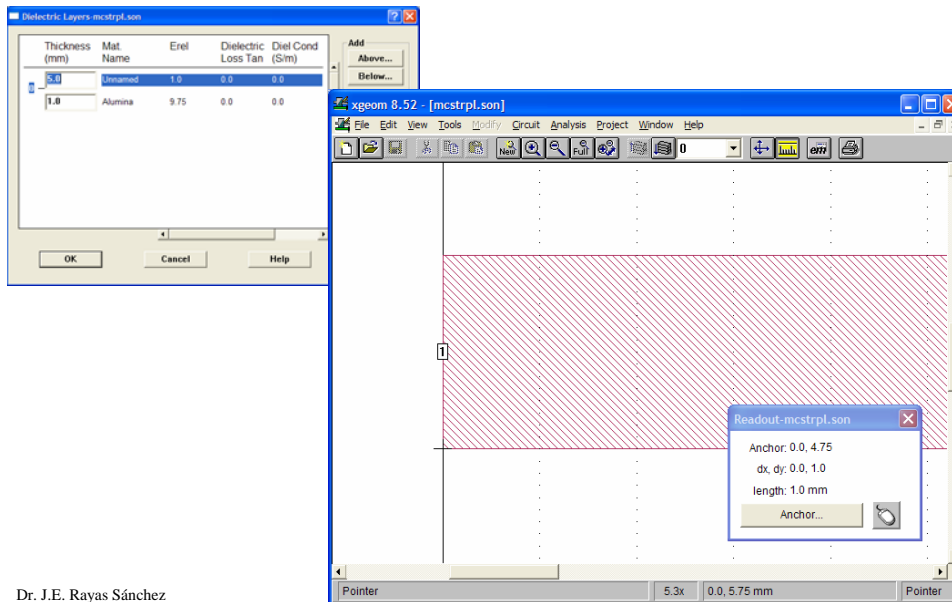
Microstrip Line Set Up – Example 5



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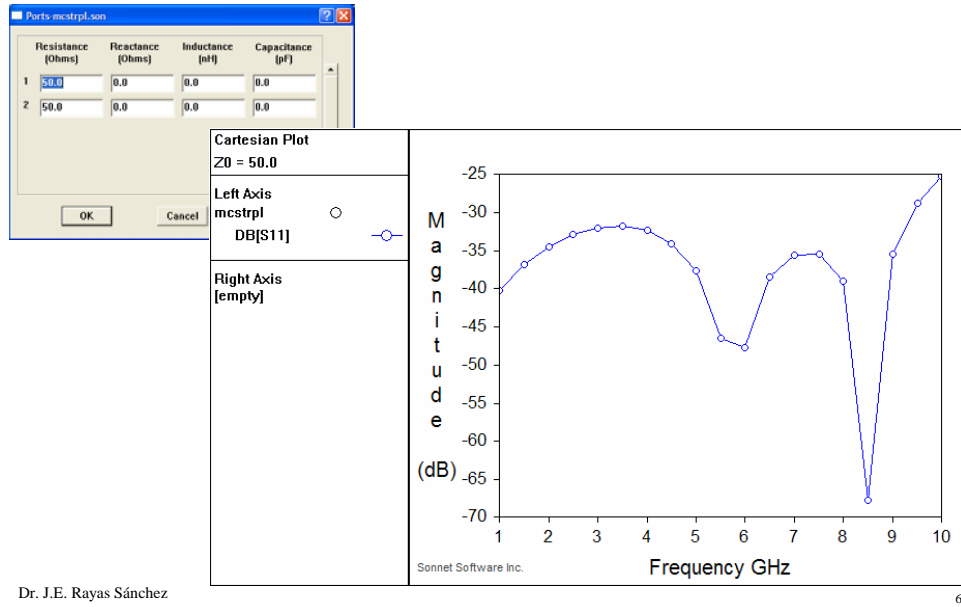
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Microstrip Line Set Up (50Ω line) – Example 5

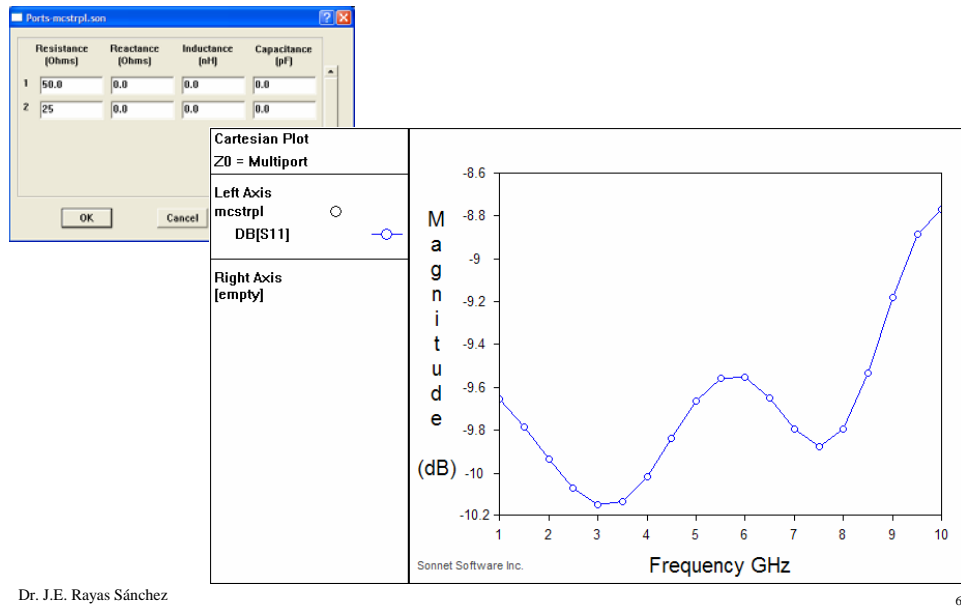


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Terminating Port 2 with 50Ω – Ex. 5



Terminating Port 2 with 25Ω – Ex. 5



Terminating Port 2 with an Open Circuit – Ex. 5

