**An Introduction to Sonnet**
Dr. José Ernesto Rayas -Sánchez
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# An Introduction to Sonnet

**Dr. José Ernesto Rayas-Sánchez**

1

## 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

https://www.sonnetsoftware.com/

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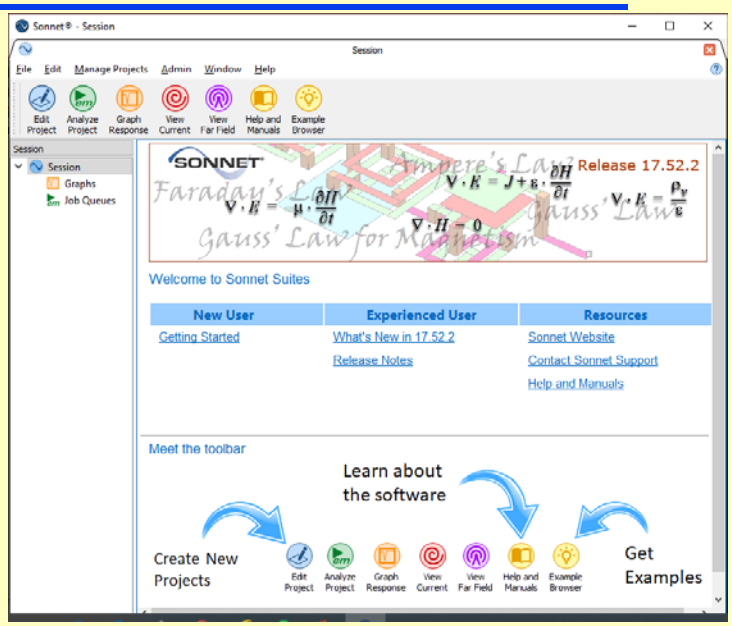
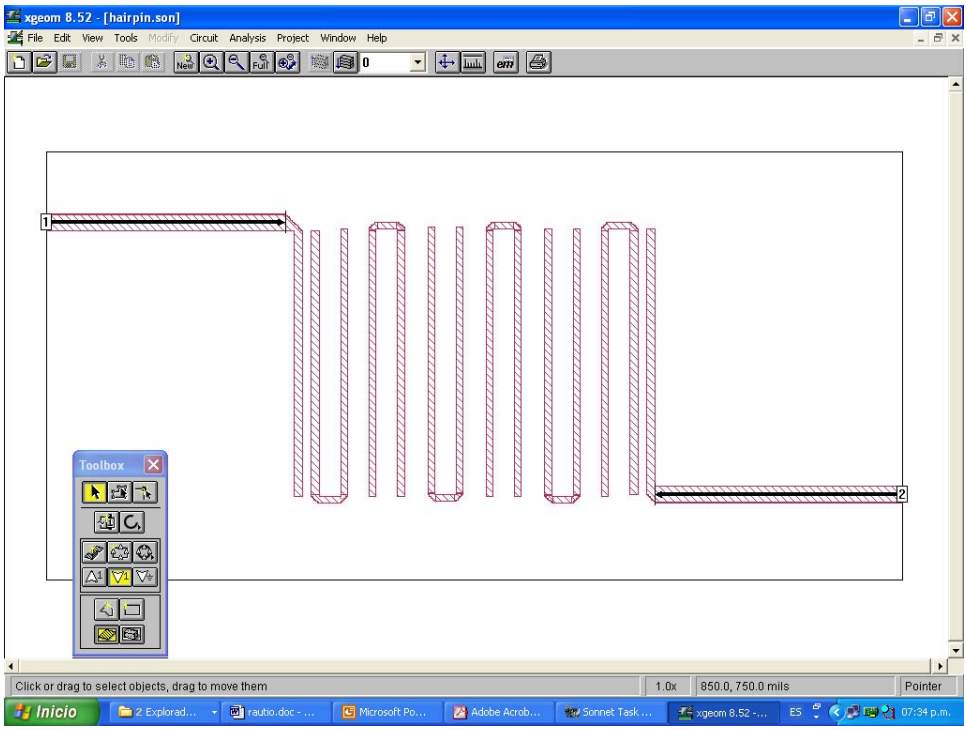
2

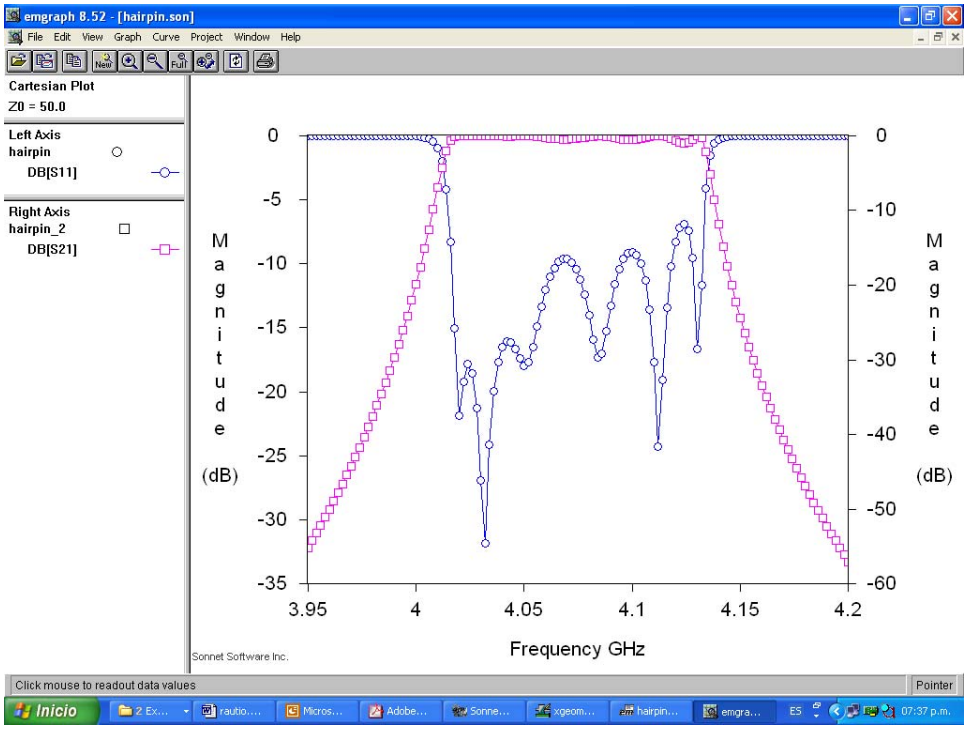
## Sonnet's User-Interface

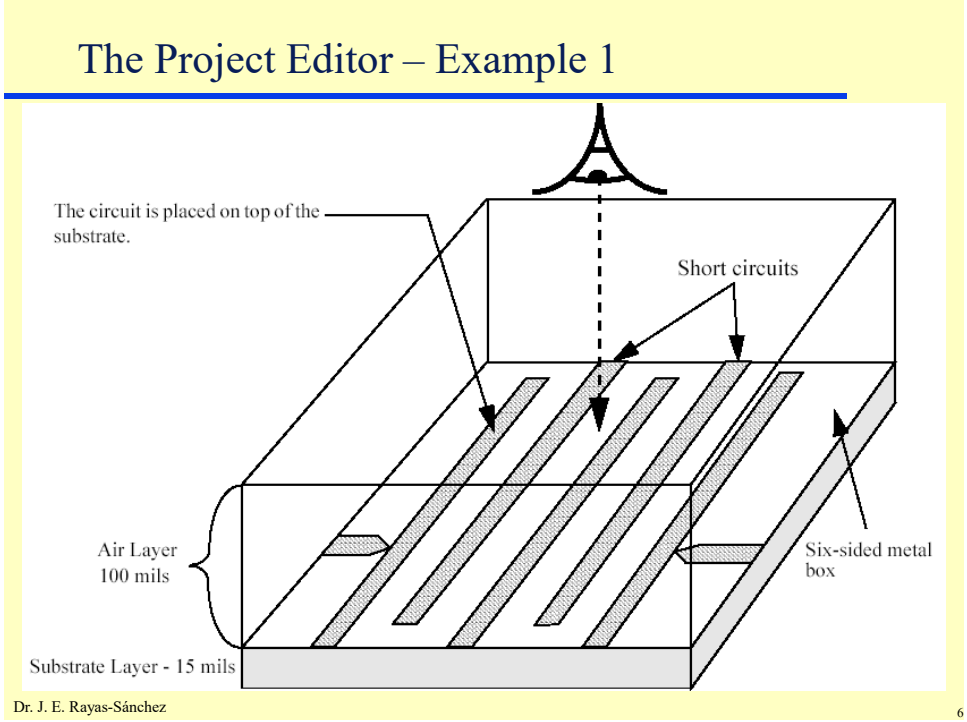
(v17.52.2)



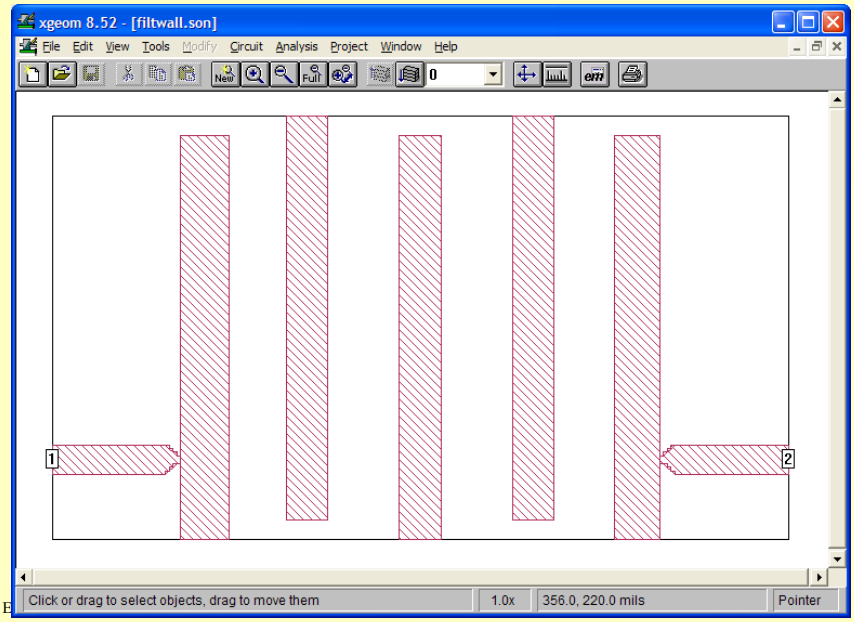

Dr. J. E. Rayas-Sánchez 3




emgraph 8.52 - [hairpin.son]
File Edit View Graph Curve Project Window Help
Cartesian Plot
Z0 = 50.0
Left Axis
hairpin
DB[S11]
Right Axis
hairpin_2
DB[S21]
Magnitude (dB)
0
-5
-10
-15
-20
-25
-30
-35
0
-10
-20
-30
-40
-50
-60
3.95
4
4.05
4.1
4.15
4.2
Frequency GHz
Sonnet Software Inc.
Click mouse to readout data values
Pointer
Inicio

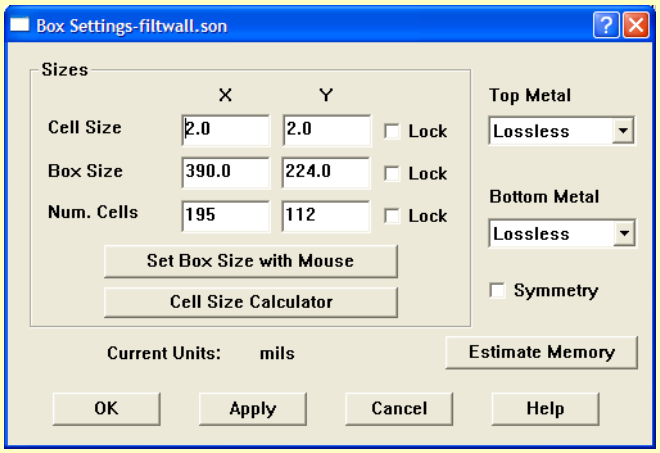

The Project Editor – Example 1
The circuit is placed on top of the substrate.
Short circuits
Air Layer
100 mils
Six-sided metal box
Substrate Layer - 15 mils
Dr. J. E. Rayas-Sánchez
6

## The Project Editor – Example 1 (cont.)

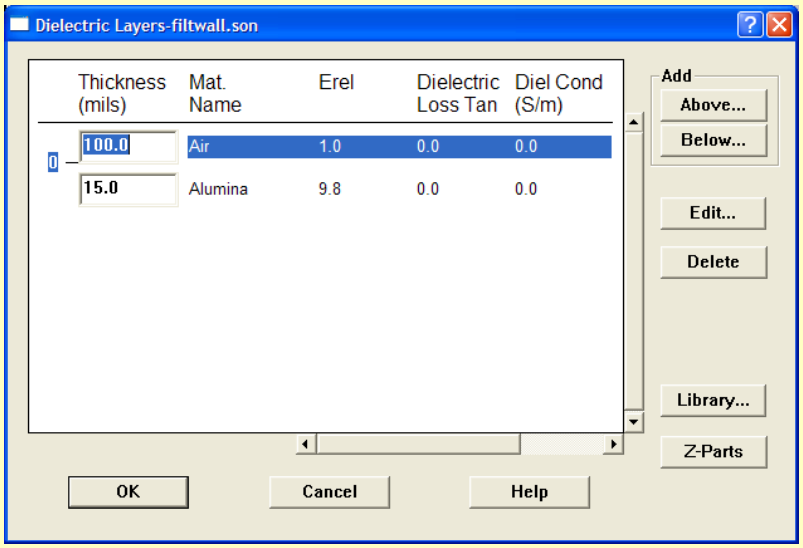





## The Project Editor – Example 1 (cont.)

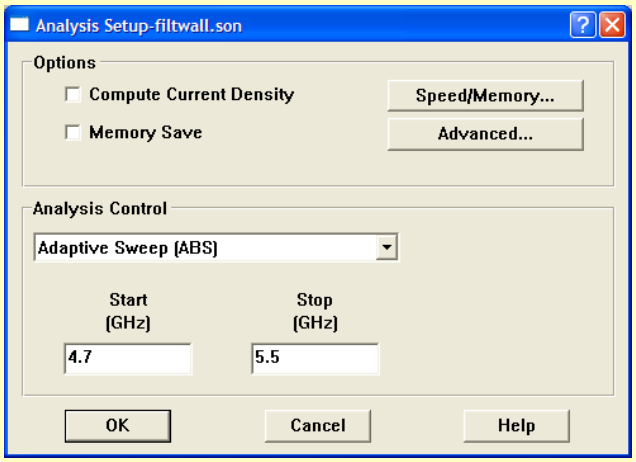


## The Project Editor – Example 1 (cont.)

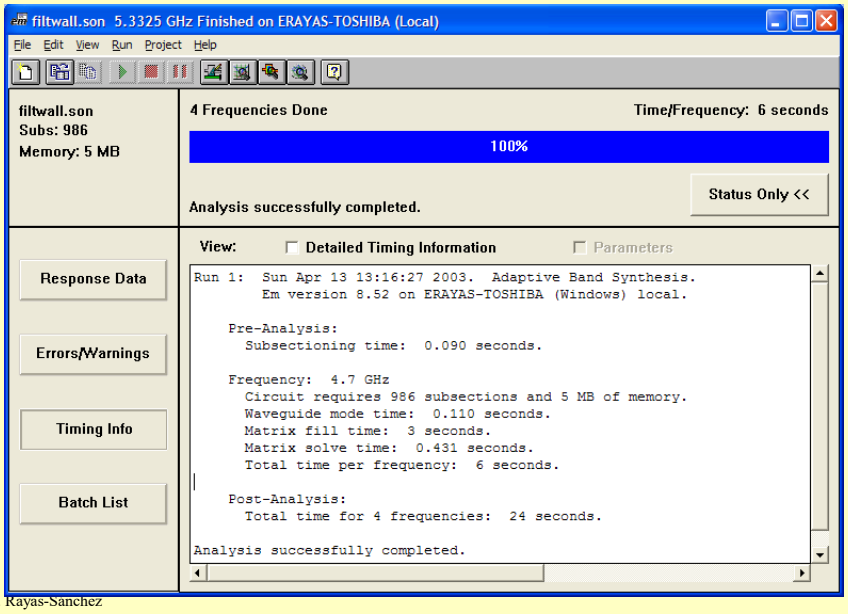





## Setting-up the Analysis – Example 1

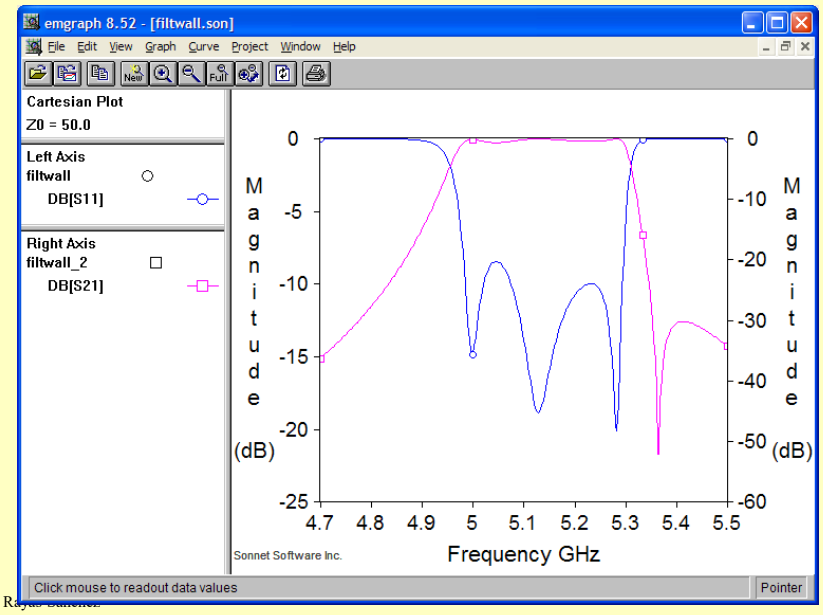


# Running the Simulation – Example 1

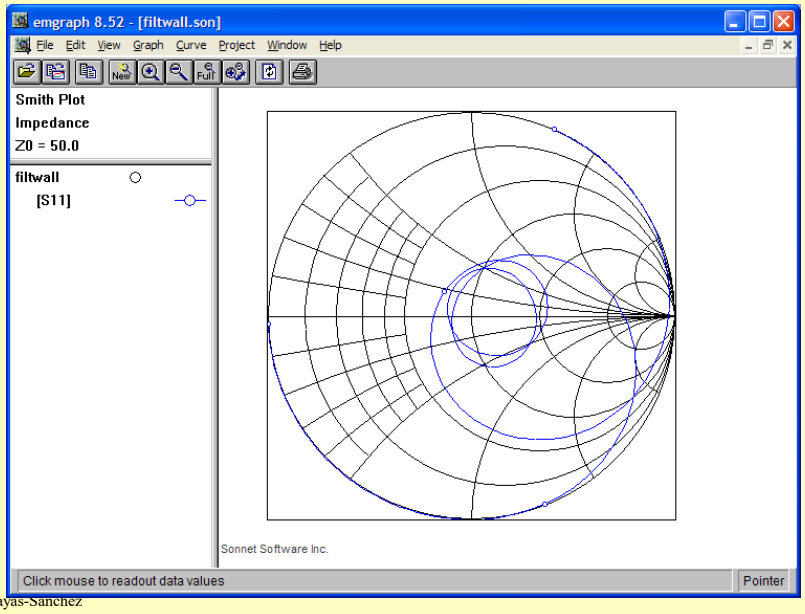





# Showing Results – Example 1

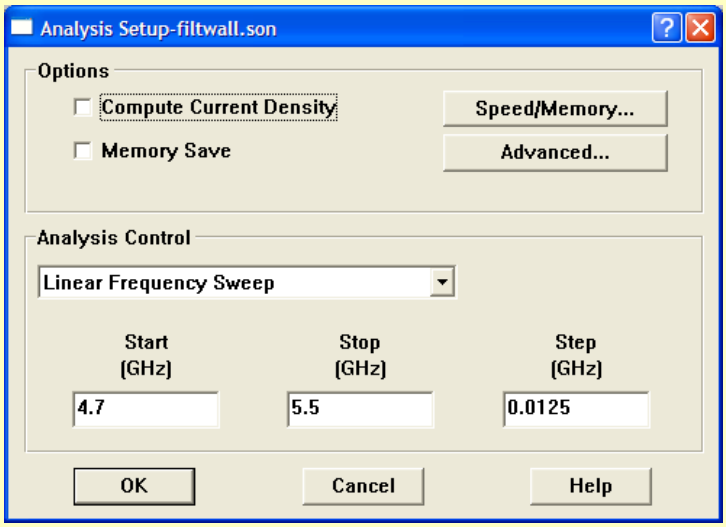


## Showing Results – Example 1 (cont.)

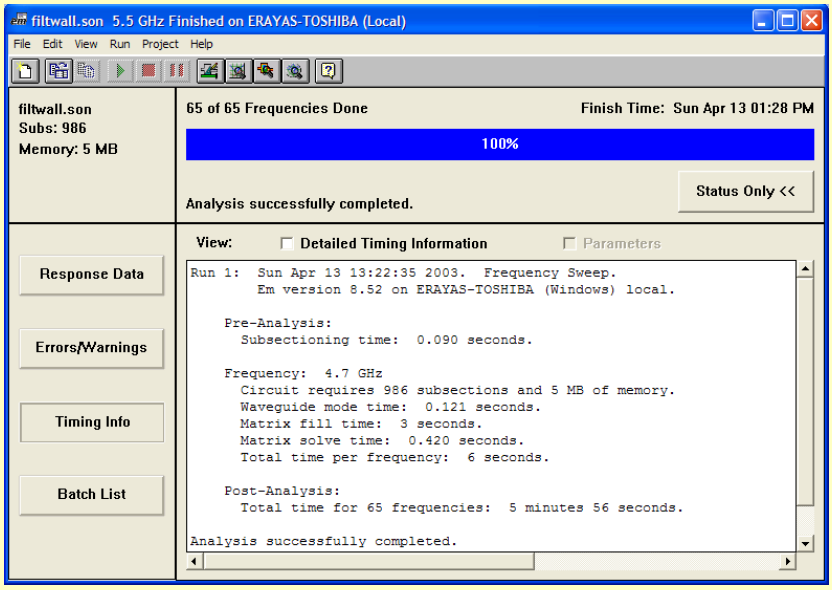





## Setting-up the Analysis – Example 1 (cont.)

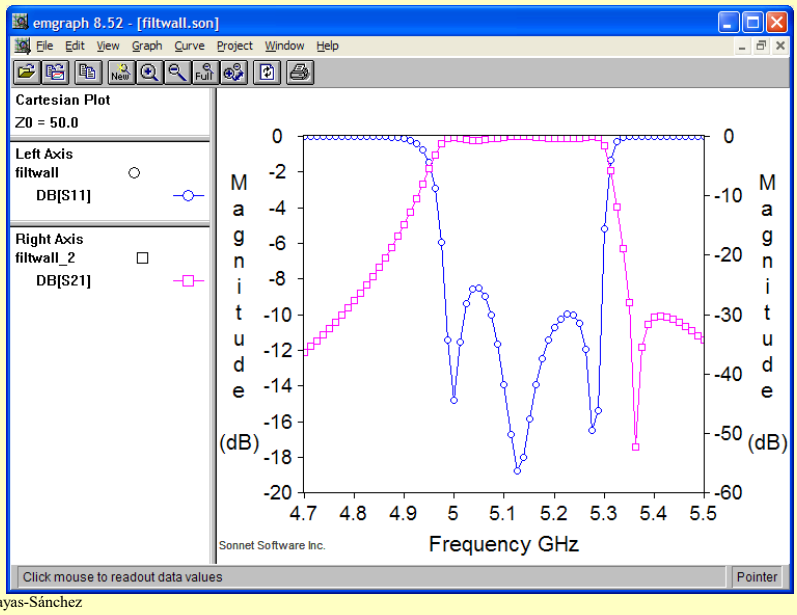


## Running the Simulator – Example 1 (cont.)

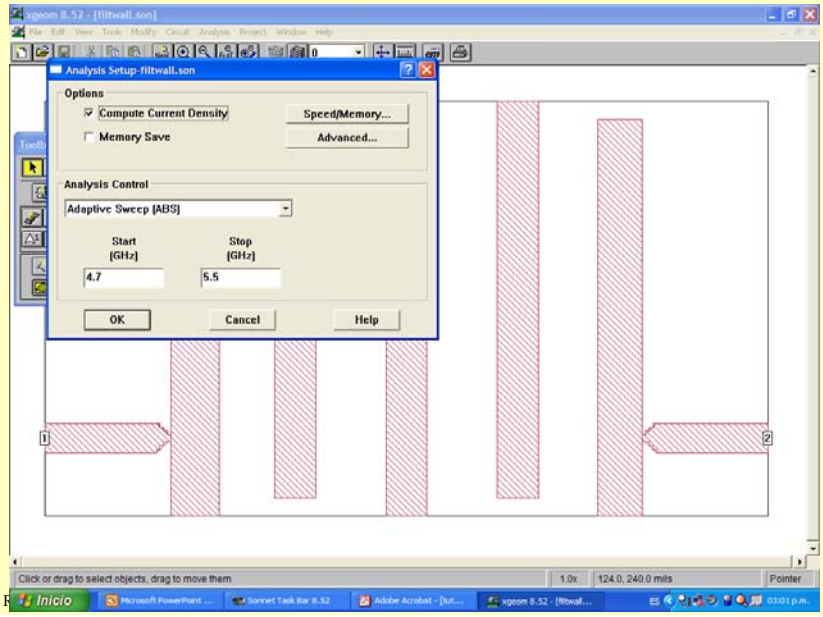





## Showing Results – Example 1 (cont.)

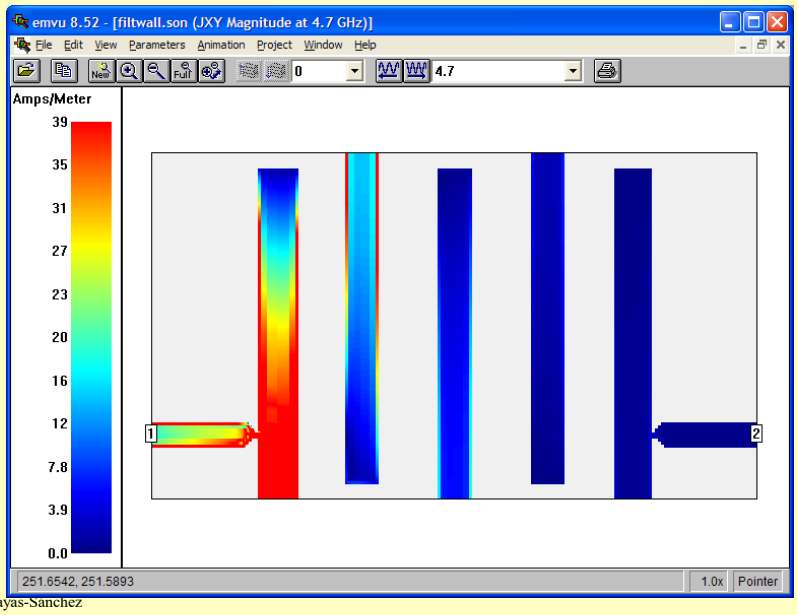


## Current Density Viewer – Example 1 (cont.)

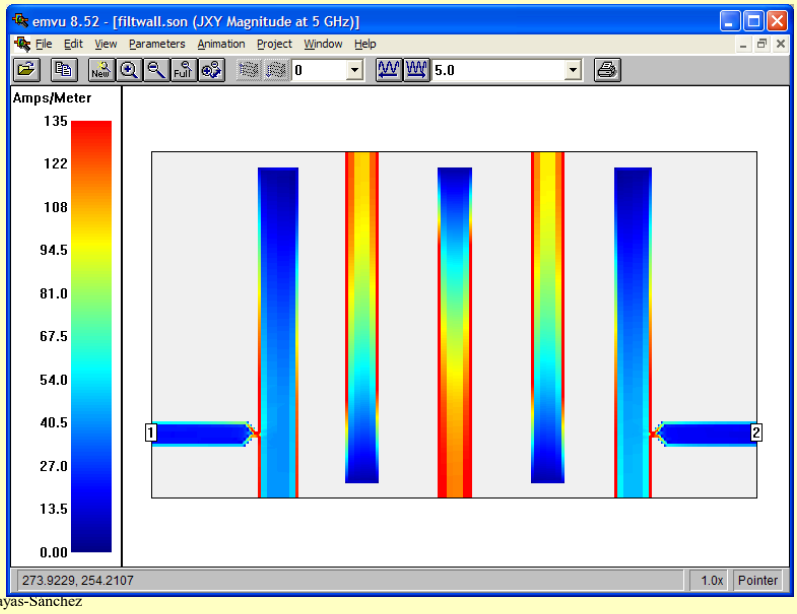





## Current Density Viewer – Example 1 (cont.)

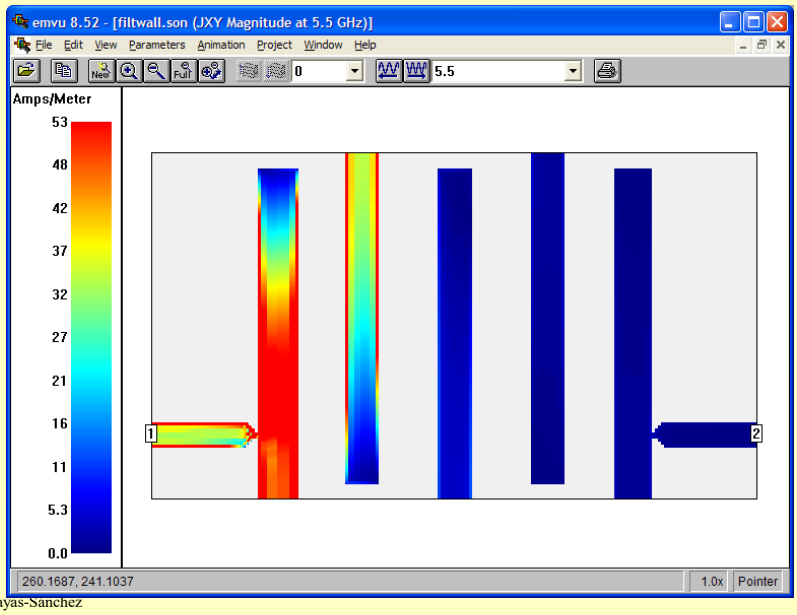


## Current Density Viewer – Example 1 (cont.)




Dr. J. E. Rayas-Sanchez 19

## Current Density Viewer – Example 1 (cont.)




Dr. J. E. Rayas-Sanchez 20

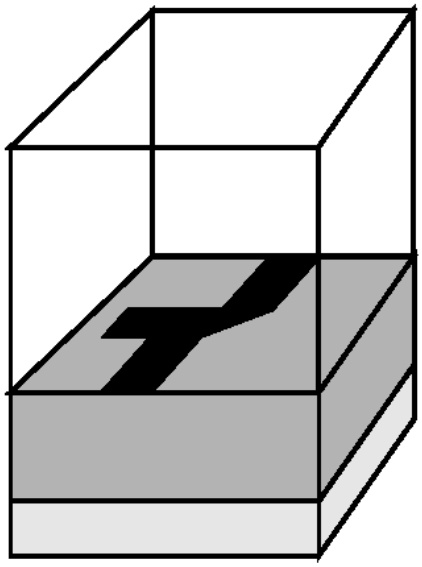
## The Substrate, Subsectioning, and Cell Size

- 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

  Cell Size × Number of Cells = 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

Dr. J. E. Rayas-Sánchez 21

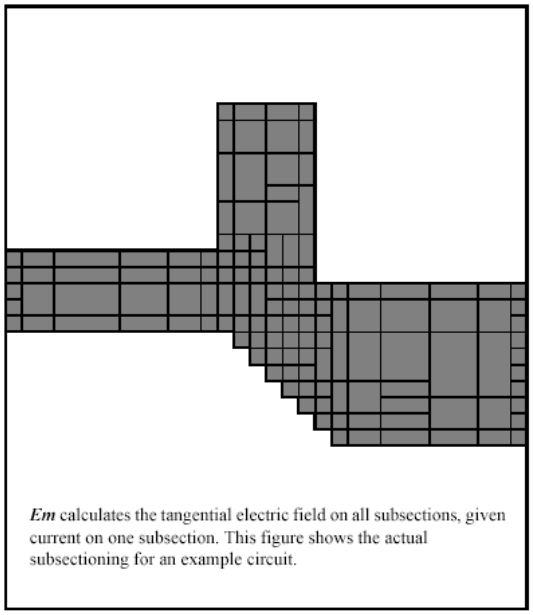
## The Box and the Substrate



***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.

Dr. J. E. Rayas-Sánchez 22

## Subsectioning

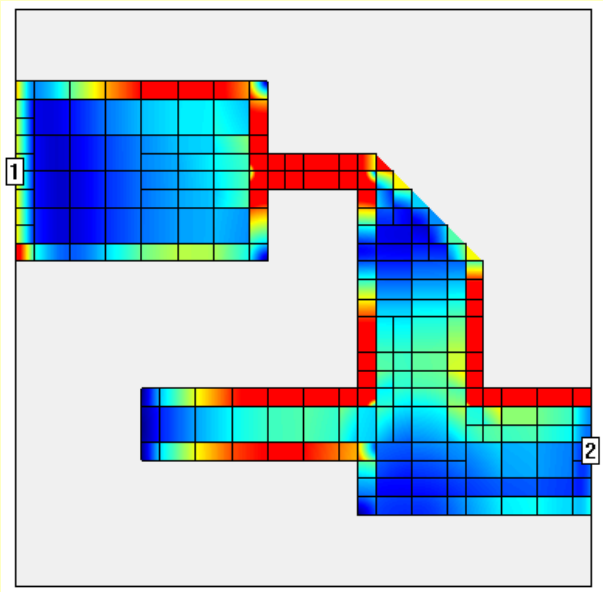


***Em*** calculates the tangential electric field on all subsections, given current on one subsection. This figure shows the actual subsectioning for an example circuit.

Dr. J. E. Rayas-Sánchez

23

## Subsectioning (cont.)




Dr. J. E. Rayas-Sánchez

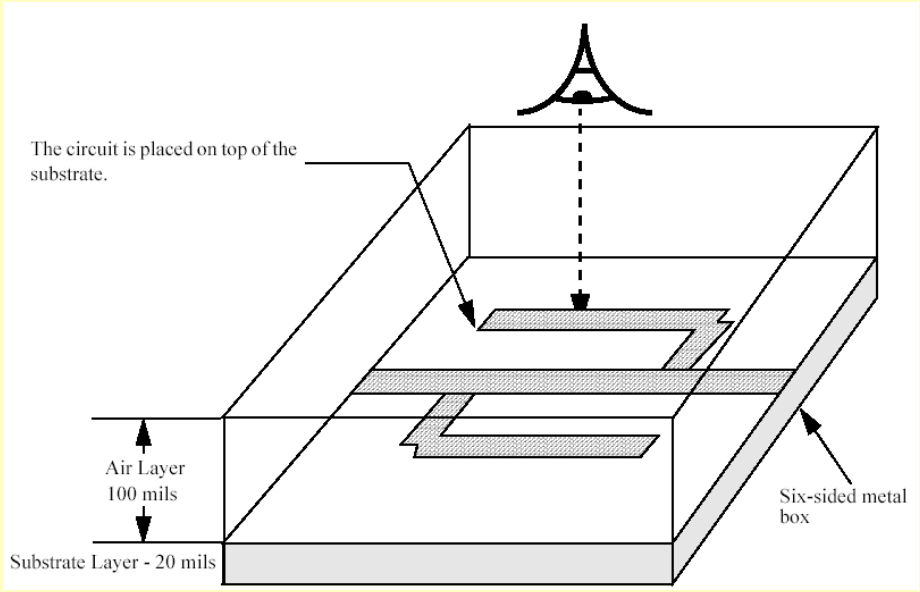
24

## Metalization Levels and Dielectric Layers

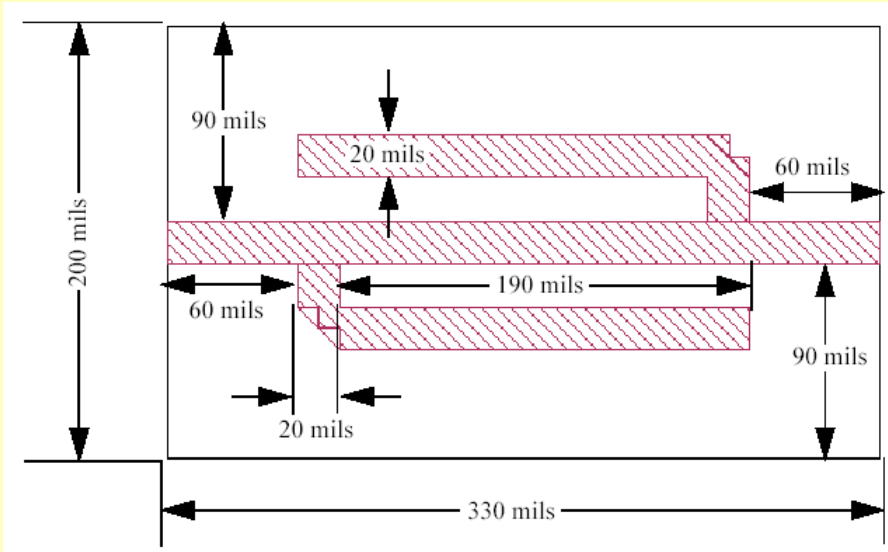
- Sonnet Professional can handle any number of metalization levels
- Metalization is refered to as “levels” and dielectric as “layers”
- Each metalization level is sandwiched between two dielectric layers



## Example 2: A Double Folded Stub Filter

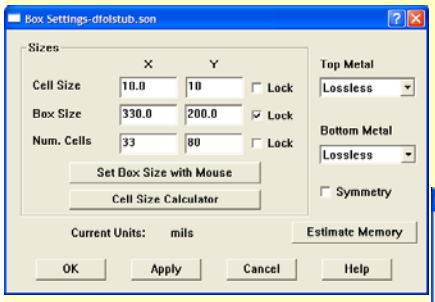


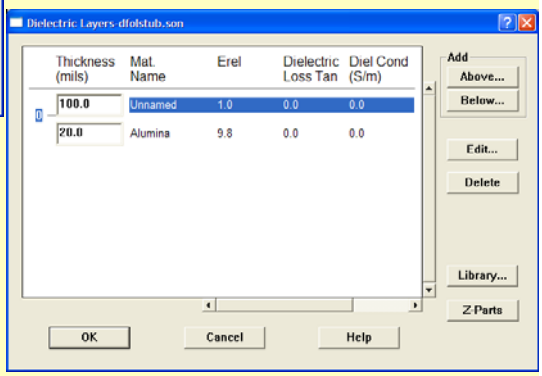
## Example 2: A Double Folded Stub Filter (cont.)




Dr. J. E. Rayas-Sánchez 27

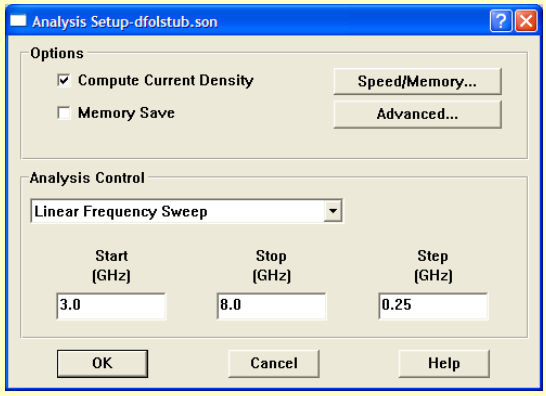
## Setting up the Structure – Example 2




Dr. J. E. Rayas-Sánchez 28

## Setting up the Analysis – Example 2




$$\lambda_{\min} = \frac{c}{f_{\max}\sqrt{\varepsilon_e}}$$

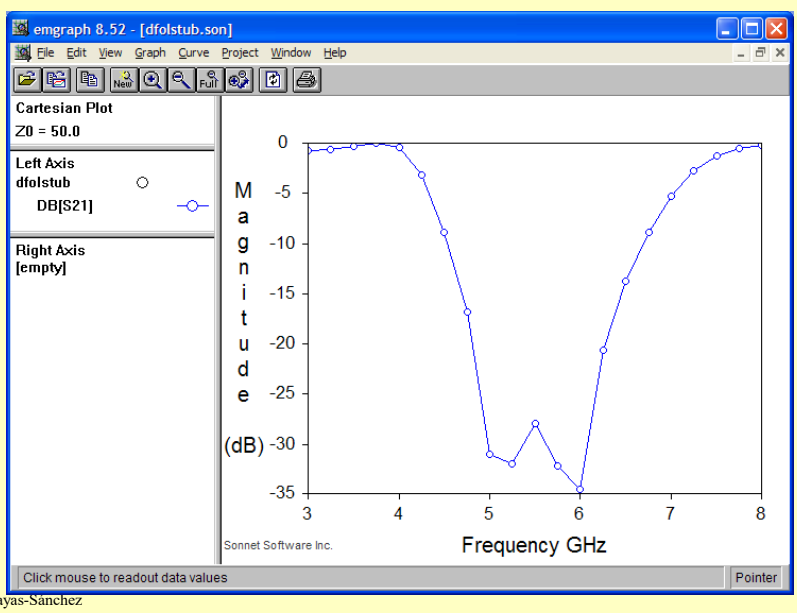
$$\lambda_{\min} \approx \frac{300\text{Mm/s}}{8\text{GHz}\sqrt{9.8}}$$

$\lambda_{\min}$ = 11.98 mm = 471.61 mil

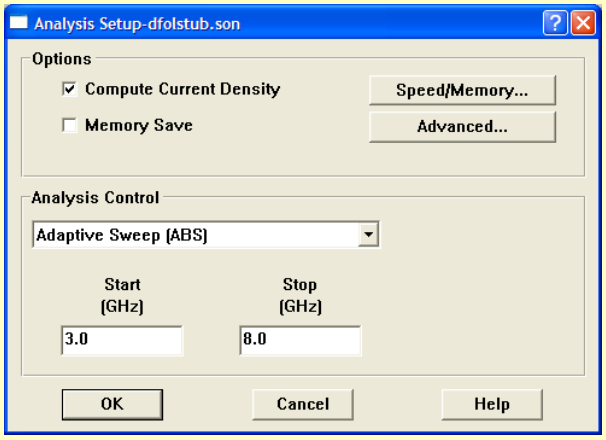
$\lambda_{\min}$ / 20 = 23.58 mil  Cell size < 23.58 mil



## Results – Example 2

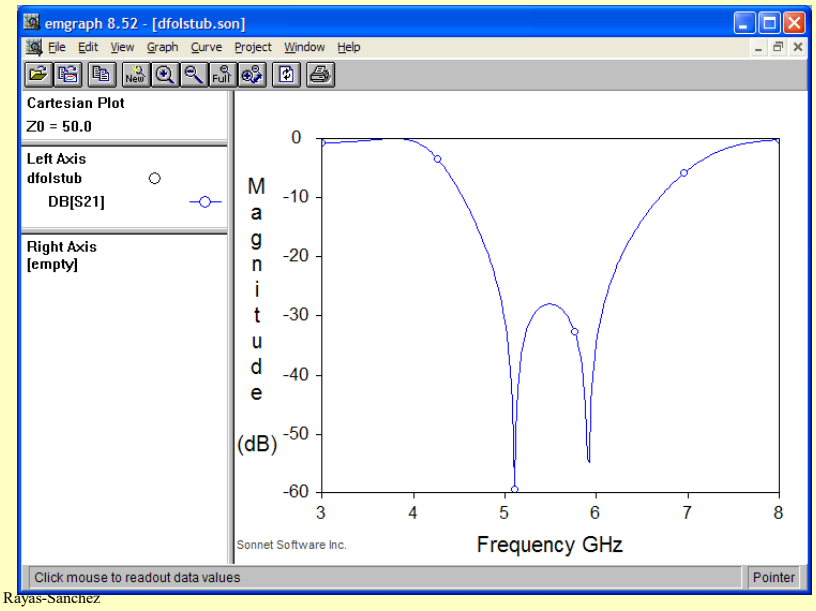


# Using Adaptive Frequency Sweep – Example 2

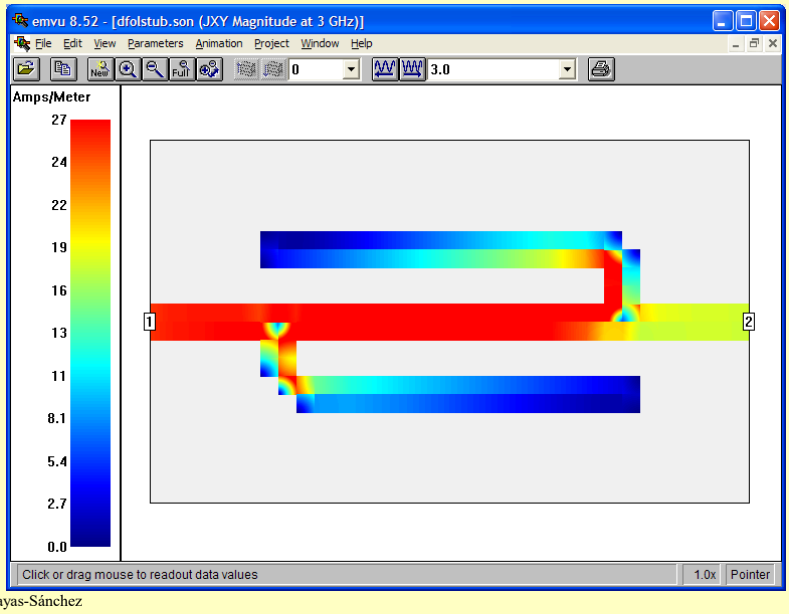





# Results – Example 2

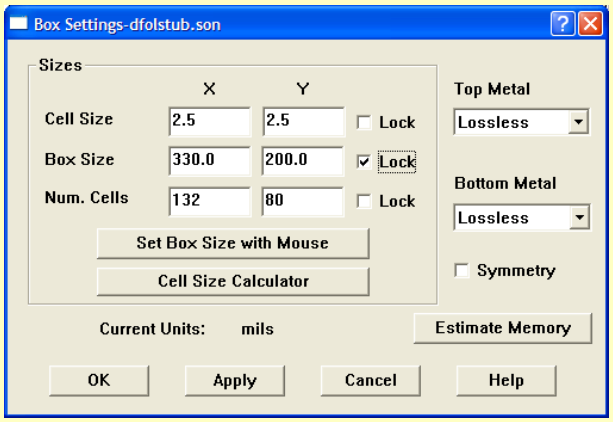


# Results – Example 2

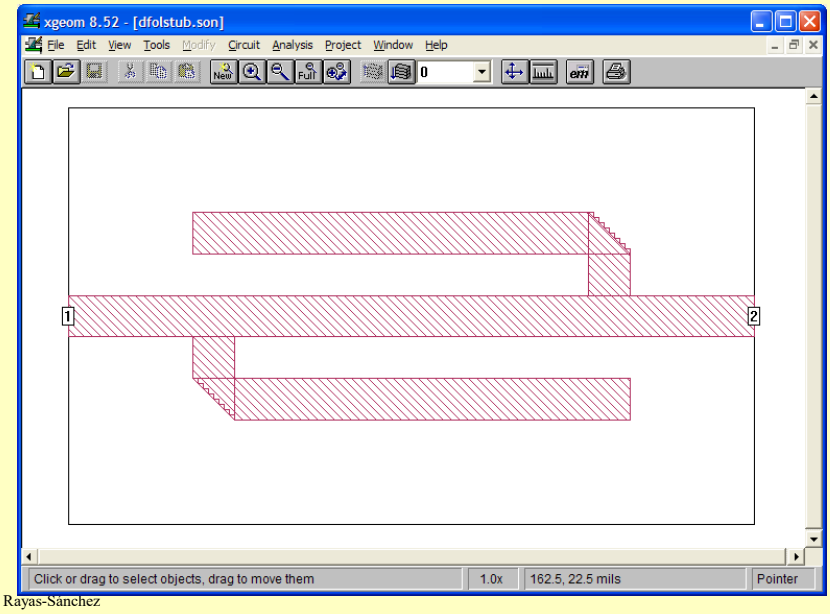





# Increasing Resolution – Example 2

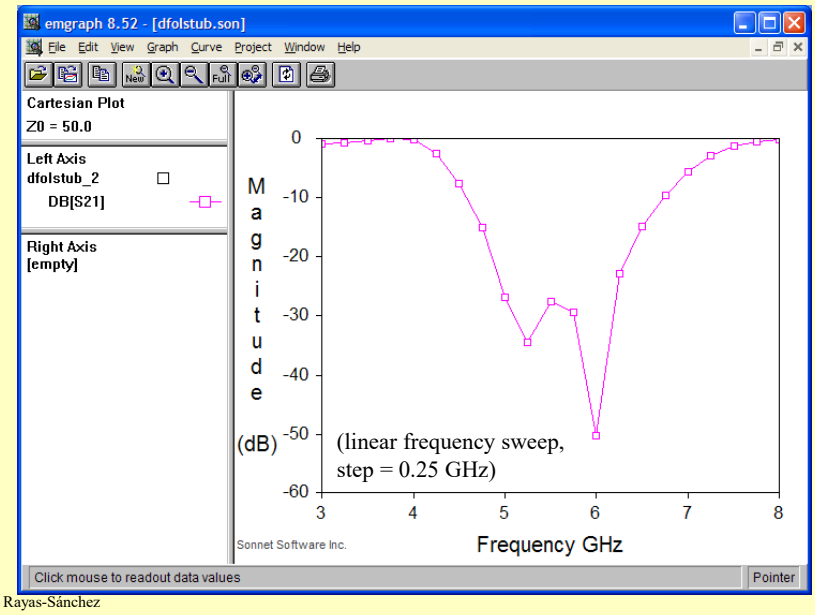


## Increasing Resolution – Example 2 (cont.)

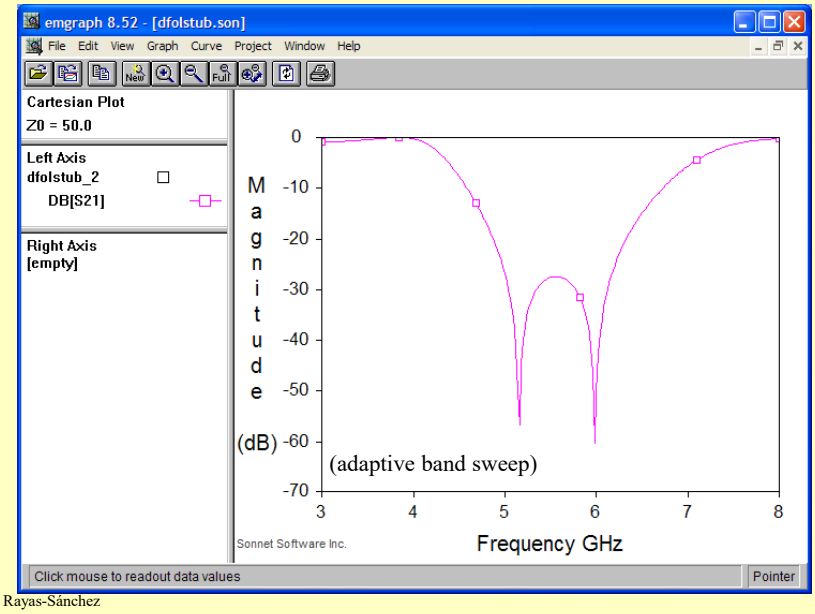





## Increasing Resolution – Example 2 (cont.)

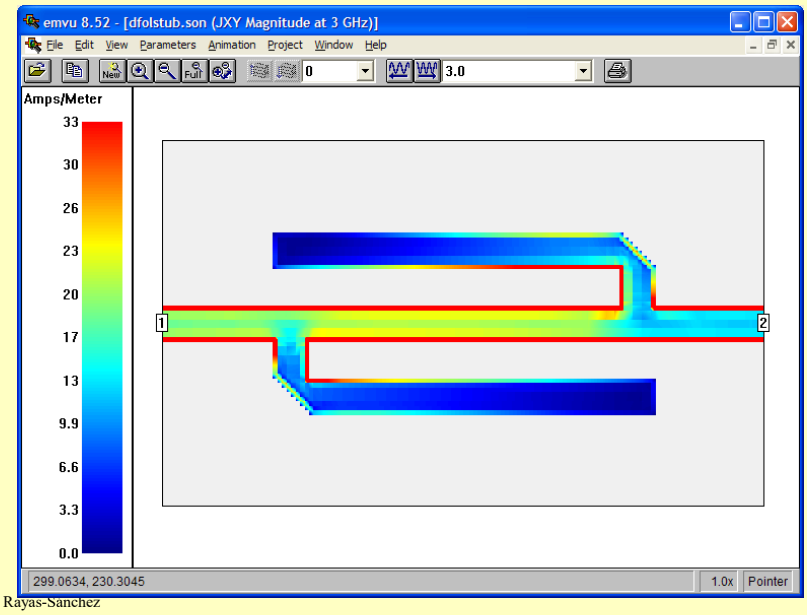


## Increasing Resolution – Example 2 (cont.)





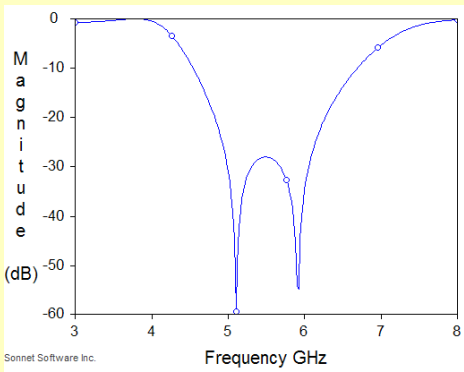

## Increasing Resolution – Example 2 (cont.)



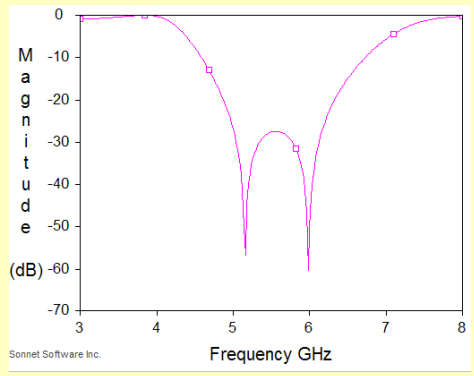
## Increasing Resolution – Example 2 (cont.)

Grid size (resolution) should be defined in terms of $\lambda_{min}$

Cell size = 10 mil



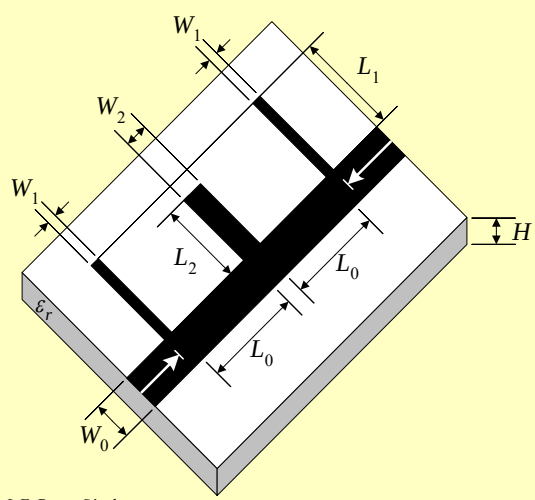

Cell size = 2.5 mil





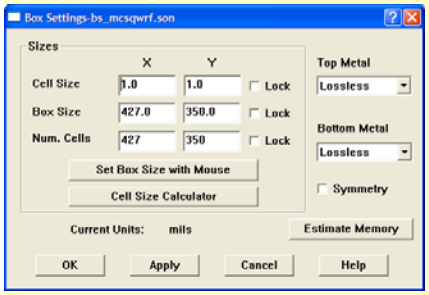

## Example 3

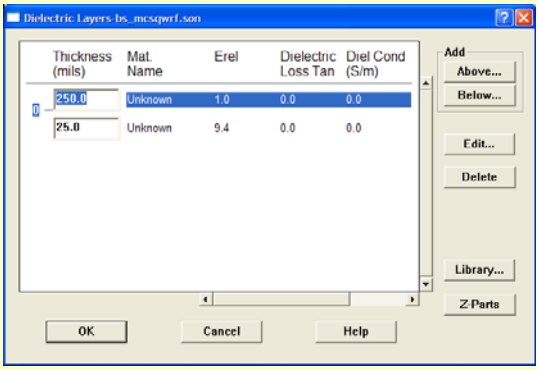
Bandstop Microstrip Filter with Quarter-Wave Open Stubs




$H = 25$ mil
$\varepsilon_r = 9.4$ (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

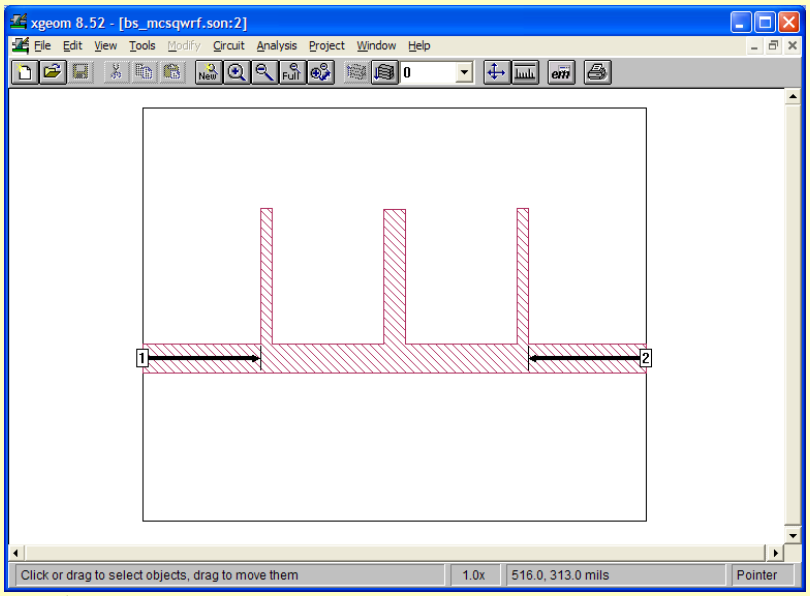
## Setting-up Structure – Example 3



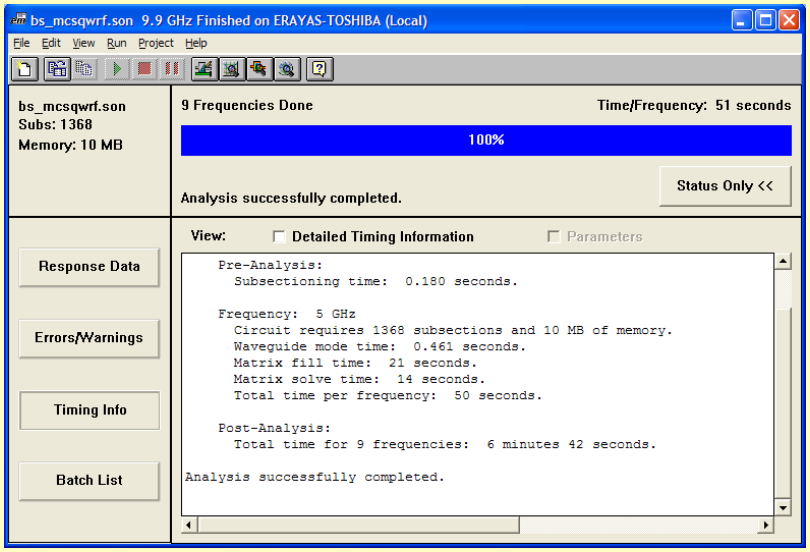

Dr. J. E. Rayas-Sánchez 41

## Structure – Example 3



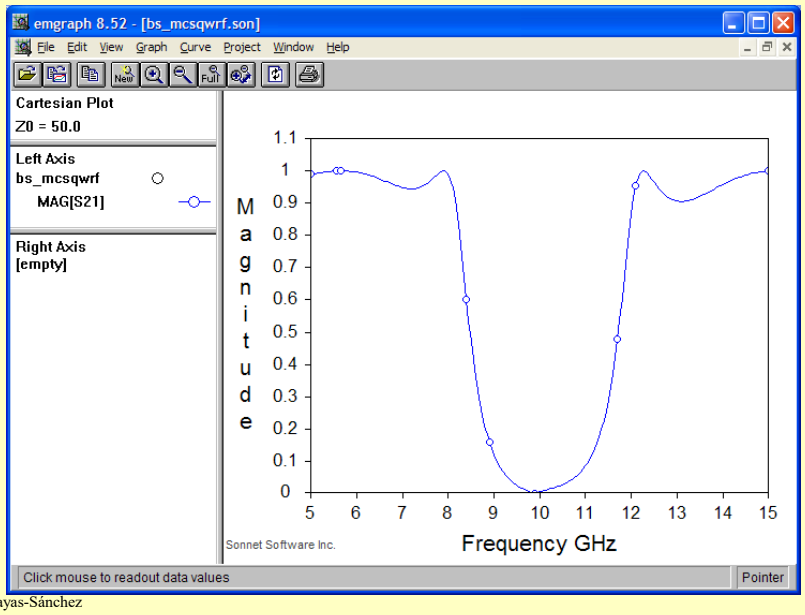

Dr. J. E. Rayas-Sánchez 42

# Simulation Time – Example 3

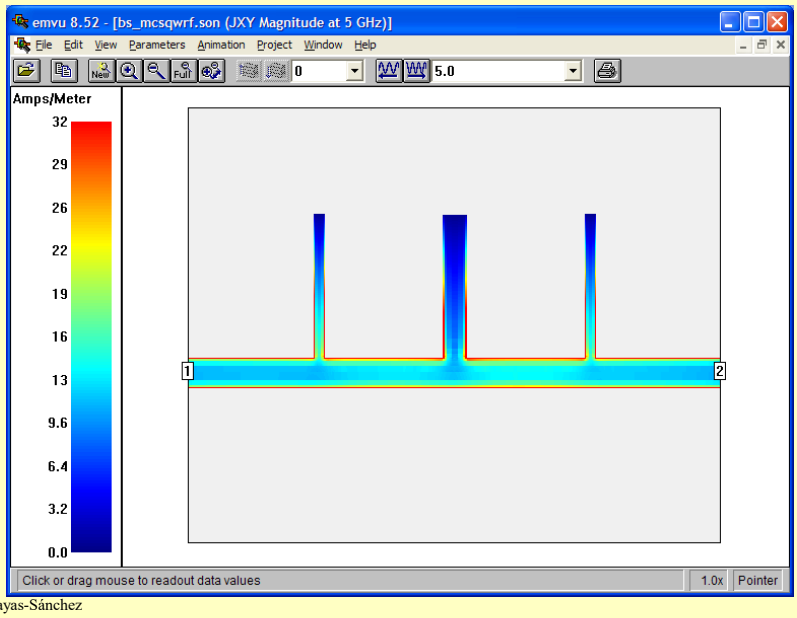





# Results – Example 3

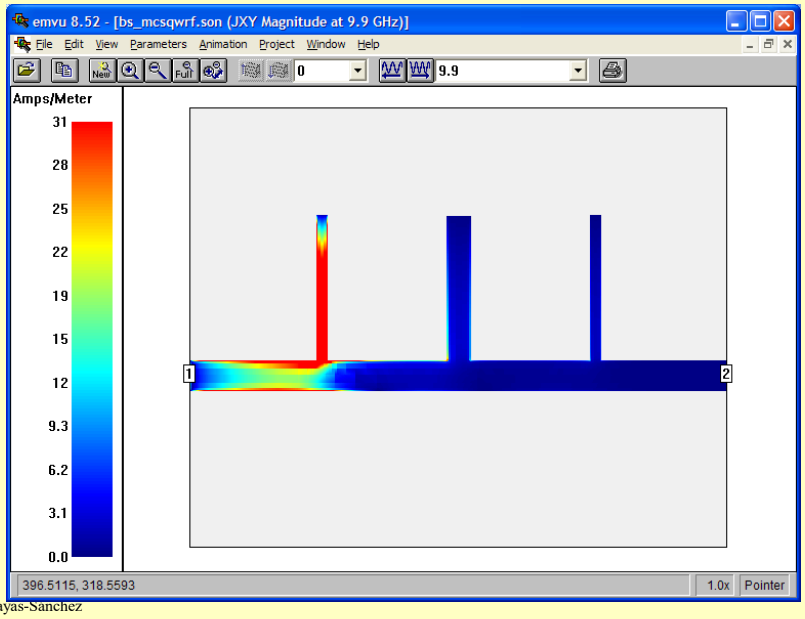


## Current Density – Example 3



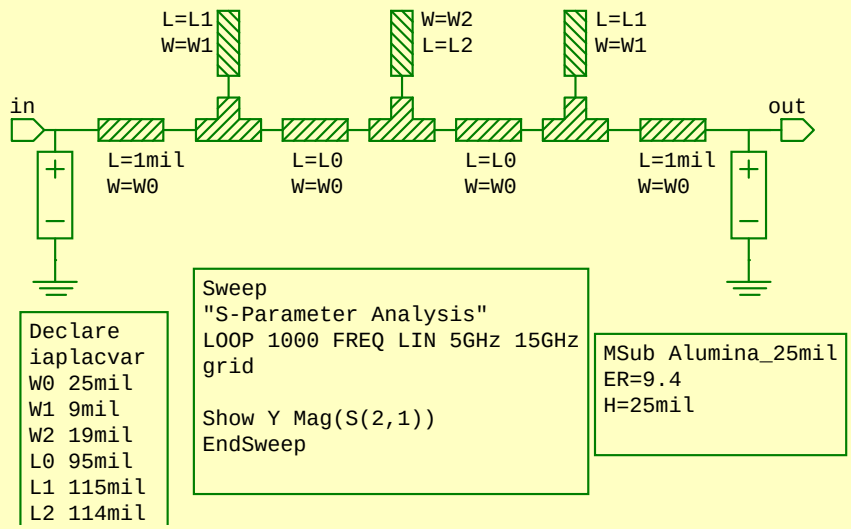

Dr. J. E. Rayas-Sánchez 45

## Current Density – Example 3 (cont.)



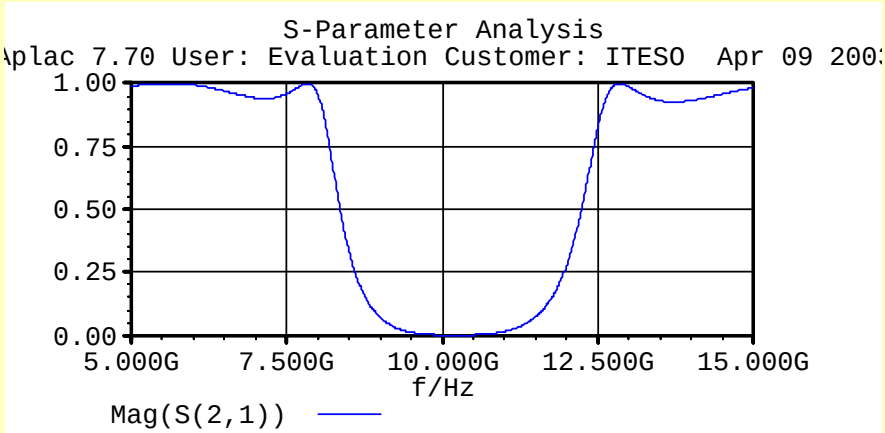

Dr. J. E. Rayas-Sánchez 46

# APLAC Model – Example 3



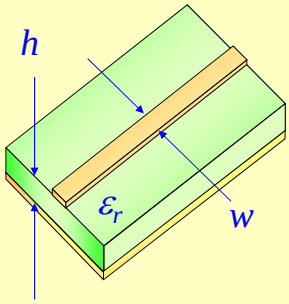

Dr. J. E. Rayas-Sánchez 47

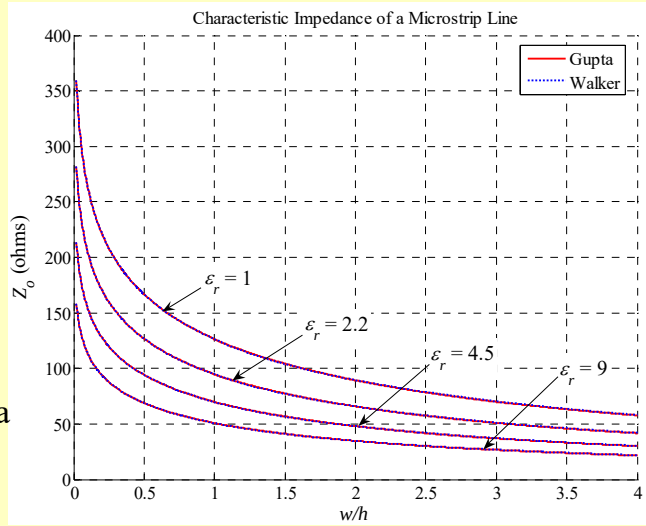
# Results using APLAC – Example 3




Dr. J. E. Rayas-Sánchez 48

# Exercise: A Simple Microstrip Line




- If $h$ = 0.66 mm and $\varepsilon_r$ = 9, select $w$ for a 50-Ω line
- Simulate in Sonnet from 0.15-15 GHz (assume $L$ = 10 mm, neglect losses)

Dr. J. E. Rayas-Sánchez 49