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EM.Picasso

Tutorial Lessons

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EM.Picasso Tutorial Lesson 3

Analyzing a Planar Microstrip Band-Stop Filter

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3.1 What You Will Learn

In this tutorial you will model a two-port planar filter that is excited by two independent scattering wave ports. You will first use a wizard to create a basic two-port microstrip through line. Then, you will add additional microstrip segments to complete your filter construction.

EM.Picasso Manual:

http://www.emagtech.com/wiki/index.php/EM.Picasso

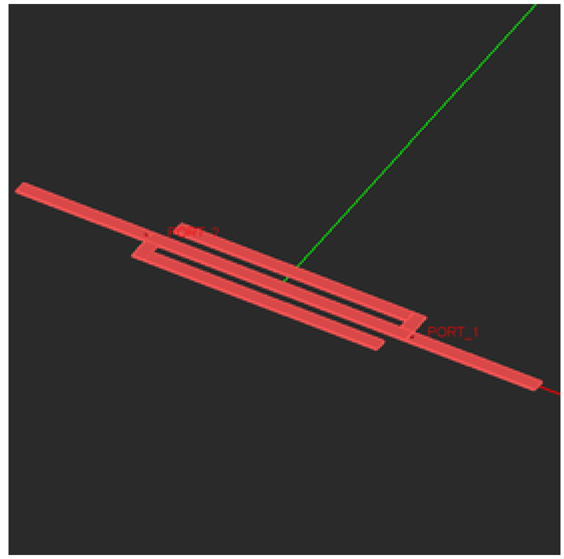
EM.Picasso Tutorial Gateway:

http://www.emagtech.com/wiki/index.php/EM.Cube#EM.Picasso_Documentation

Download projects related to this tutorial lesson:

http://www.emagtech.com/downloads/ProjectRepo/EMPicasso_Lesson3.zip

Tutorial Project: Analyzing A Planar Microstrip Band-Stop Filter



Objective: In this project, you will analyze a two-port microstrip filter structure and investigate its frequency response.

Concepts/Features:

- Rectangle Strip
- Microstrip Port Source
- Port Definition
- S-Parameters
- Return Loss
- Insertion Loss

Minimum Version Required: All versions

3.2 Getting Started

Start a new project with the following parameters:

Starting Parameters	
Name	EMPicasso_Lesson3
Length Units	Mils
Frequency Units	GHZ
Center Frequency	13GHz
Bandwidth	10GHz

Substrate Configuration	
Number of Finite Layers	1
Top Half-Space	Vacuum
Middle Layer	$\varepsilon_r = 9.9, \sigma = \sigma_m = 0$, Thickness = 5mils
Bottom Half-Space	PEC

Make sure you have changed the project units to "Mils".

3.3 Constructing the Base Geometry of a Two-Port Microstrip Line

Click on the **Two-Port Microstrip Wizard**  button of the **Wizard Toolbar** (Figure 1) or select the menu item **Tools** → **Transmission Line Wizards** → **Two-Port Microstrip Line**.

Figure 1. *EM.Picasso's Wizard Toolbar.*

A default two-port microstrip line structure appears in the project workspace (Figure 2). The structure consists of a center microstrip line segment with two feed line segments of the same width at the two sides.

You can zoom to fit your structure into the screen by clicking the **Zoom Extents**  button of **View Toolbar** or select the menu item **View** → **Zoom** → **Extents** or using the keyboard shortcut **Ctrl+E**. If you have a mouse with a scroll wheel, you can use the scroll wheel to zoom in or zoom out while you draw an object. You can also rotate the view using the right mouse button, or pan the view using the right mouse button while holding the keyboard's **Shift** Key down.

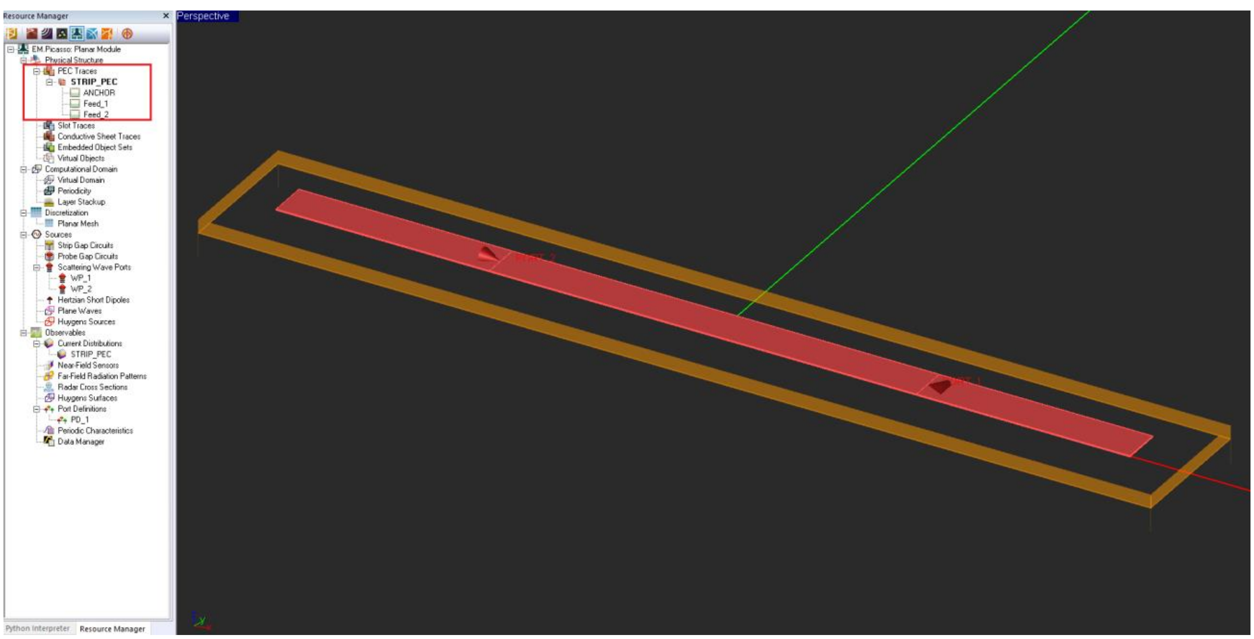


Figure 2. *The initially created two-port microstrip geometry.*

The wizard also defined and placed two **Scattering Wave Ports** on the two side feed lines. Therefore, you have a two-port structure with a 2 × 2 scattering matrix to be computed. Figure 3 shows the port definition dialog for your structure, where ports have been assigned a reference port impedance of 50Ω.

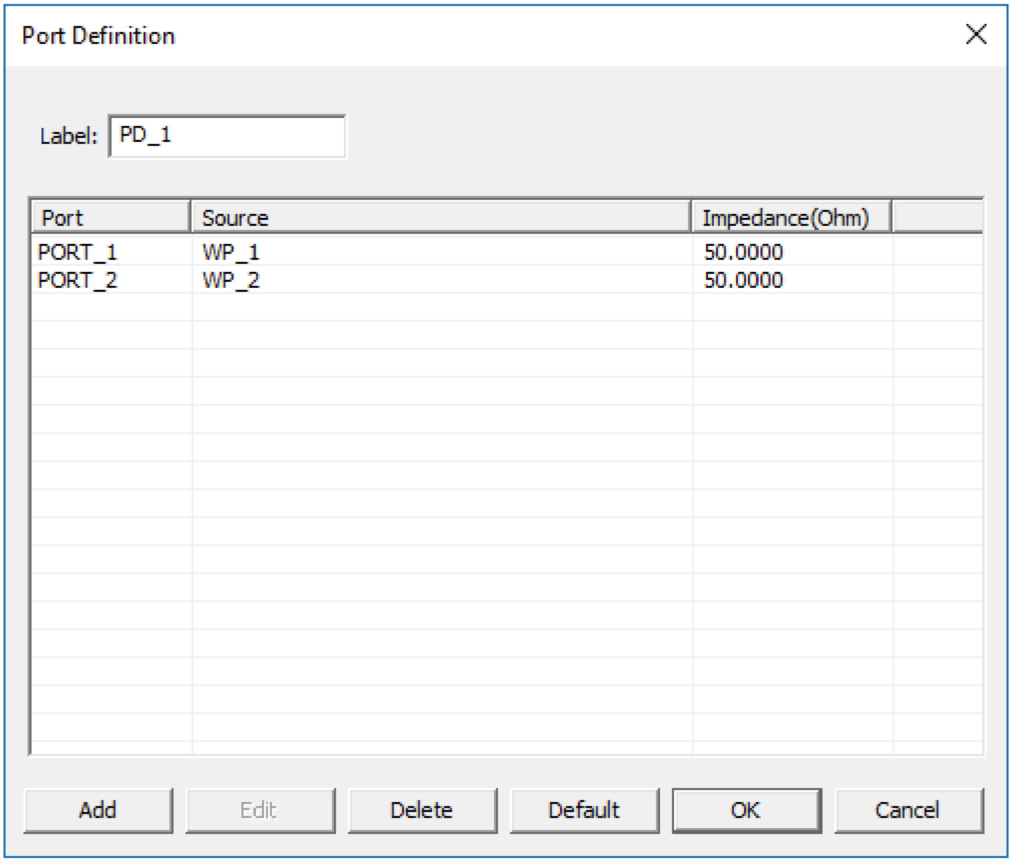


Figure 3. *The Port Definition dialog.*

At this point, you are going to change the parameters of microstrip geometry the wizard created for you including the dielectric substrate properties. Open the Variables dialog and change the definition of the following variables (Figure 4):

Variable Name	Original Definition	New Definition
er	2.2	9.9
h	0.0015*to_meters	5
center_len	0.05*to_meters	100.6
feed_len	0.5*cetner_len	50
feed_wid	floor(microstrip_design(z0,er)*h*100)/100	4.8

Some of the above length variables have original definitions that convert default meter-scaled values to the project units of your current project. This is done using the system variable "to_meters". You can simply replace this kind of variables with numeric values expressed in the current project units. Also, note that on a 5-mil substrate with $\varepsilon_r = 9.9$, a 50Ω microstrip line has a width of 4.815 mils. Here you change the width of the micostrip to a rounded value of 4.8 mils. Once you make all the changes, the microstrip structure may shrink significantly.

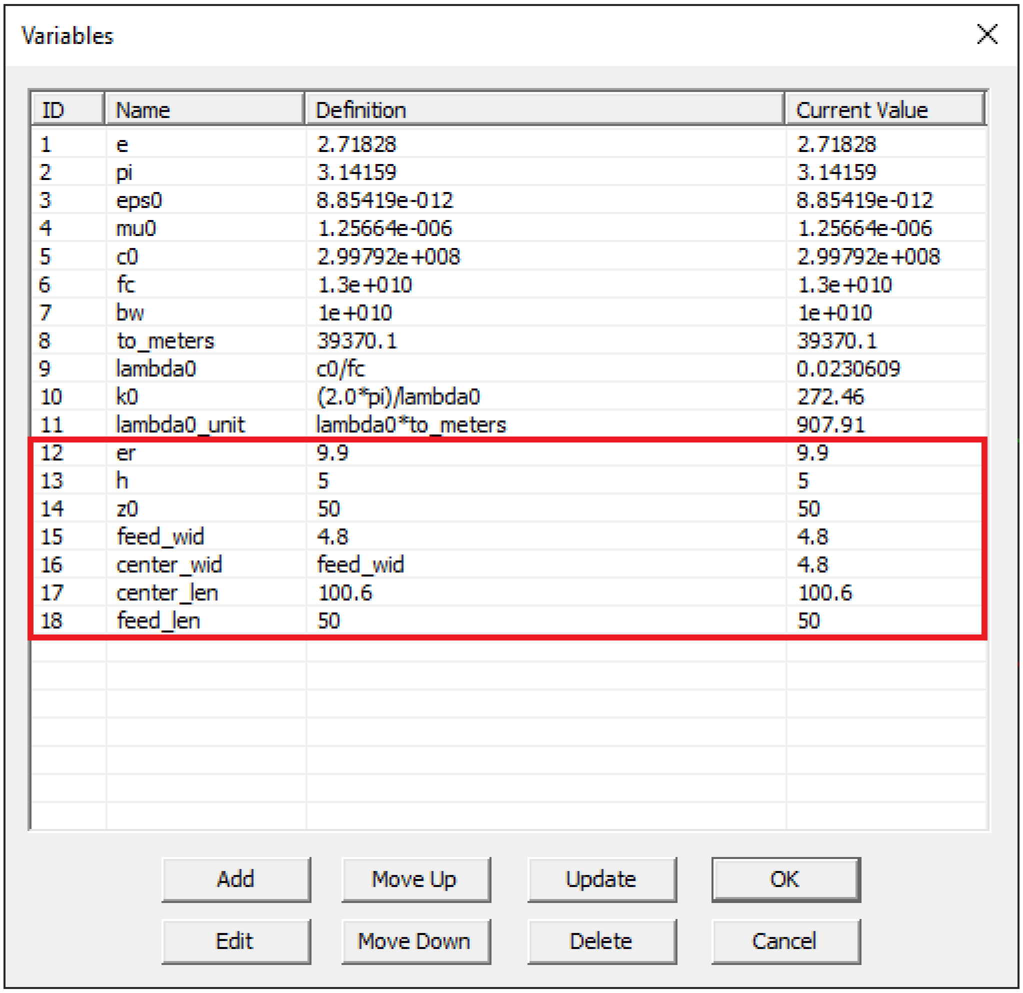


Figure 4. *The Variables dialog showing all the modified variables.*

3.4 Drawing the Additional Microstrip Components

The next step is adding four additional microstrip segments to turn the microstrip through line into a planar filter. But first you have to make sure that the objects you are going to draw will belong to the right trace group. To do so, select the item "STRIP_PEC" under **PEC Objects** in the navigation tree, right-click on it and select **Activate** from the contextual menu (Figure 5). This makes the PEC group called "CONDUCTOR" the active material group of the project for drawing and adding new objects.

Below is a list of the rectangle strip objects you need to draw in the project workspace:

Part	Object Type	Coordinates	Dimensions
Rect1	Rectangle Strip	(0.5mils, 8.8mils, 5mils)	90mils × 4.8mils
Rect2	Rectangle Strip	(-0.5mils, -8.8mils, 5mils)	90mils × 4.8mils
Rect3	Rectangle Strip	(47.9mils, 6.8mils, 5mils)	4.8mils × 8.8mils
Rect4	Rectangle Strip	(-47.9mils, -6.8mils, 5mils)	4.8mils × 8.8mils

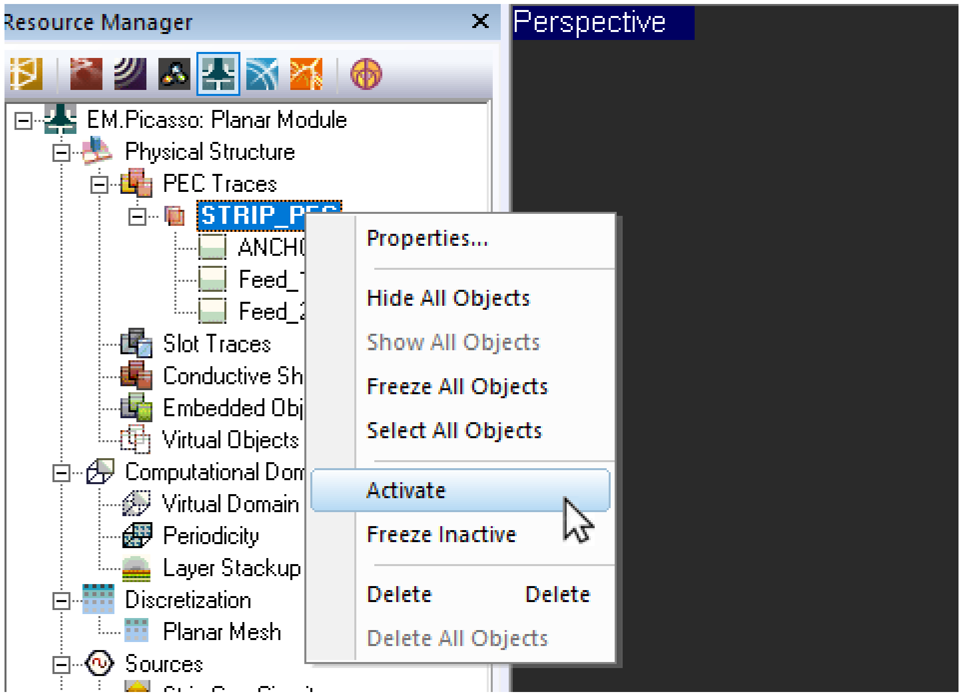


Figure 5. *Activating an object group in the navigation tree.*

There are many different ways of drawing, moving and manipulating objects in EM.Cube. As you learn more about EM.Cube's CAD tools and become more skilled in using them, you will find a number of facilitating shortcuts that take advantage of object snap points. But for now, you can simply draw the objects below on a blank space in the project workspace and then place them in the right locations by changing their coordinated according to the above table.

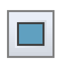
To draw a rectangle, click the **Rect Strip**  button of the **Object Toolbar** (Figure 6) or select the menu item **Object** → **Surface** → **Rectangle Strip**, alternatively, use the keyboard shortcut **Alt+R**:

Figure 6. *Selecting the Rectangle Strip tool in the Object Toolbar.*

With the rectangle strip tool selected, click on a blank space in the project workspace and drag the mouse to draw the planar rectangle object. A property dialog opens up at the lower right corner of your screen (Figure 7). As you drag the mouse, you will see that the X-dimension and Y-dimension of your new object continuously change. When the base reaches the desired size or something close to that, click the mouse. You can always fine-tune the size of your object by entering exact numeric values for its dimensions. You will notice four small red balls on the four sides (edges) of the rectangle strip object. These are called edit handles and can be used to change the dimensions of the object. Or you can simply type in any value for the X- and Y-dimensions of your rectangle. Next, you have to position your rectangle strip in the right location by entering the given values for the coordinates of the center of the local coordinate system (LCS).

In EM.Picasso, the Z-coordinates of all objects are determined by the position of their trace group in the stackup layer hierarchy, and you cannot change them.

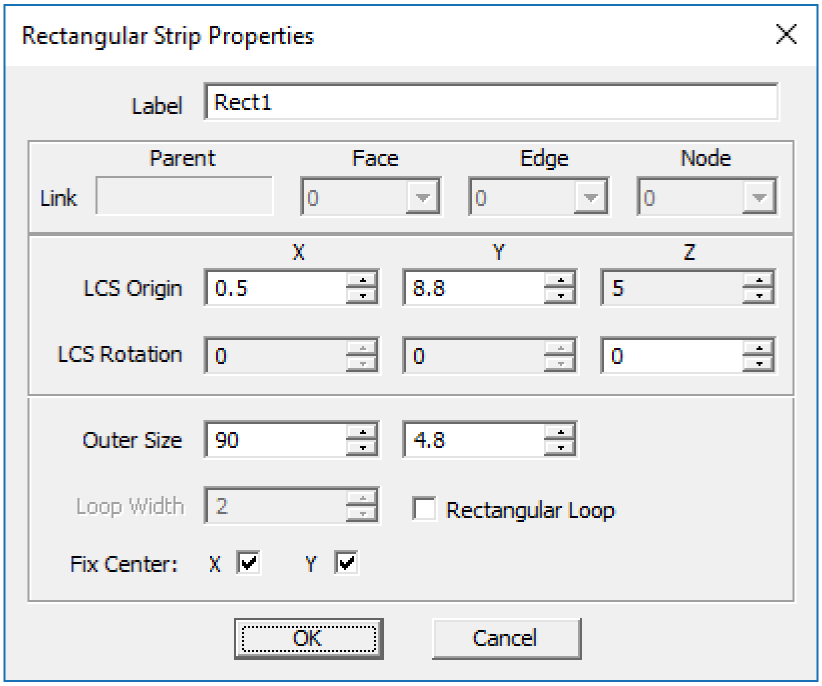


Figure 7. *The property dialog of the rectangle strip object.*

You can also use copy and paste tools to draw rectangles. For example, select "Rect1" by clicking on it. Its color changes to bright yellow, which is the default selection color. Click the **Copy**  button of the **System Toolbar** at the top of the project workspace or simply use the keyboard shortcut **Ctrl+C**. Next, click the **Paste**  button of the **System Toolbar** or simply use the keyboard shortcut **Ctrl+V** to place a copy of the selected object.

After drawing and positioning all the four rectangle strips, you filter geometry will look like figure 8 as shown below:

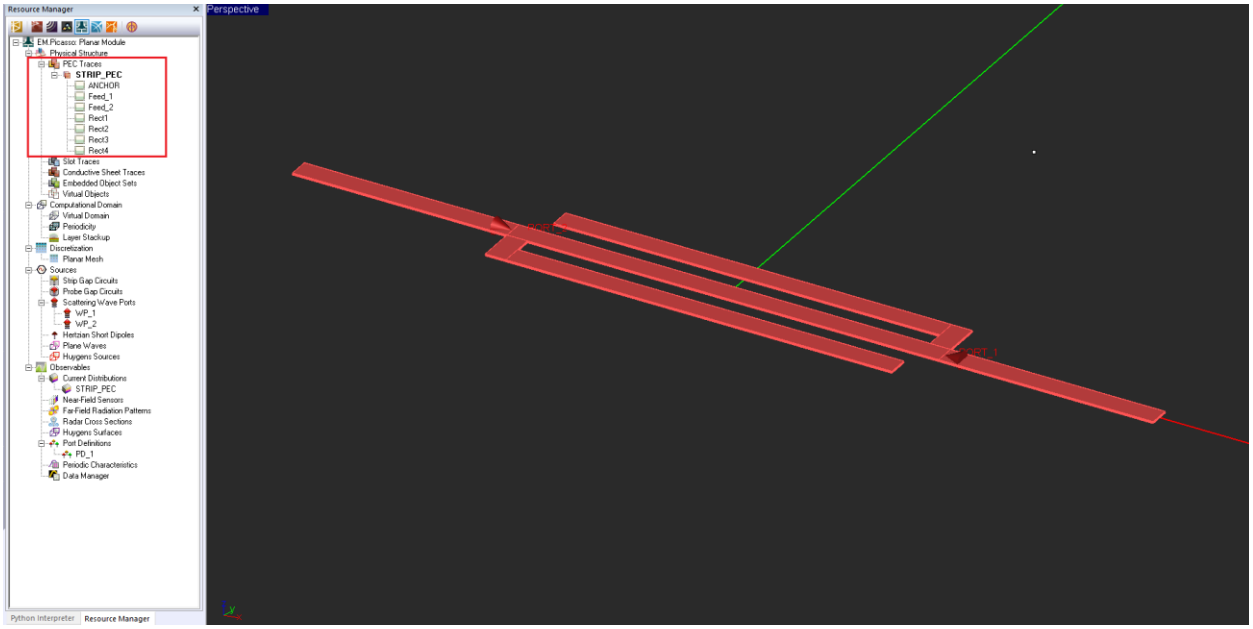


Figure 8. *The completed two-port microstrip filter geometry.*

Examine the planar mesh of your filter structure and make sure it does not contain any unusual or abnormal cells. The wizard automatically set the mesh density to 30 Cells/λ_{eff} (Figure 9).

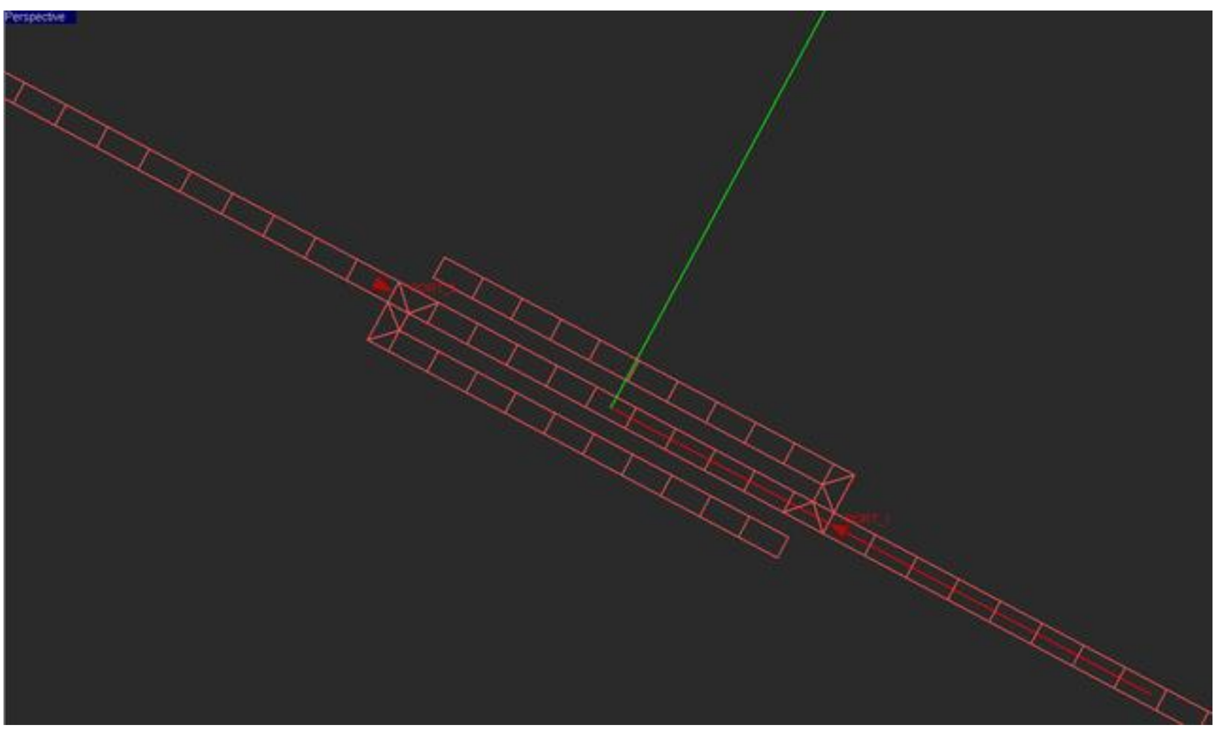


Figure 9. *The planar mesh of the two-port microstrip filter geometry.*

3.5 Running a Frequency Sweep of Your Filter Structure

At this point, your filter structure is ready for simulation. Set up a frequency sweep with the following parameters:

Start Frequency	8GHz
End Frequency	18GHz
No. Samples	11
Fix Mesh at Center Frequency	

Once the sweep simulation is finished, $N^2 = 4$ scattering parameter files are listed in the data manager. Plot the data files "S11_Sweep.CPX" and "S211_Sweep.CPX" (Figures 10 and 11). These plots represent the return loss and insertion loss of your filter, respectively.

Next, open the Data Manager and perform a Smart Fit with **Interpolant Order** of 3. Then plot the data files "S11_Sweep_RationalFit.CPX" and "Z11_Sweep_RationalFit.CPX" (Figure 12 and 13). The filter features a 4.5GHz stop band over the frequency range [10GHz - 14.5GHz].

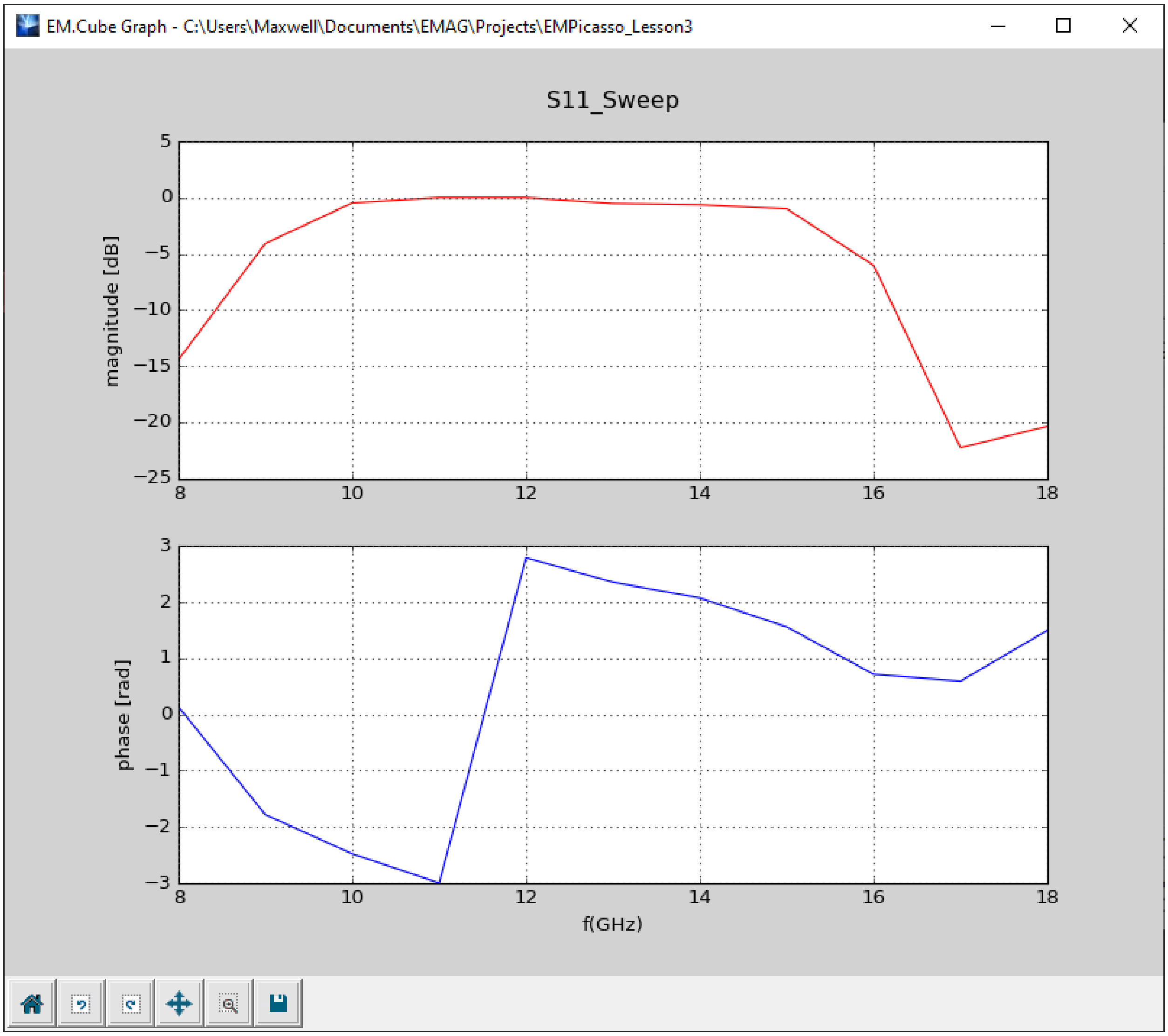


Figure 10. *The plot of S_{11} parameter of the microstrip filter structure.*

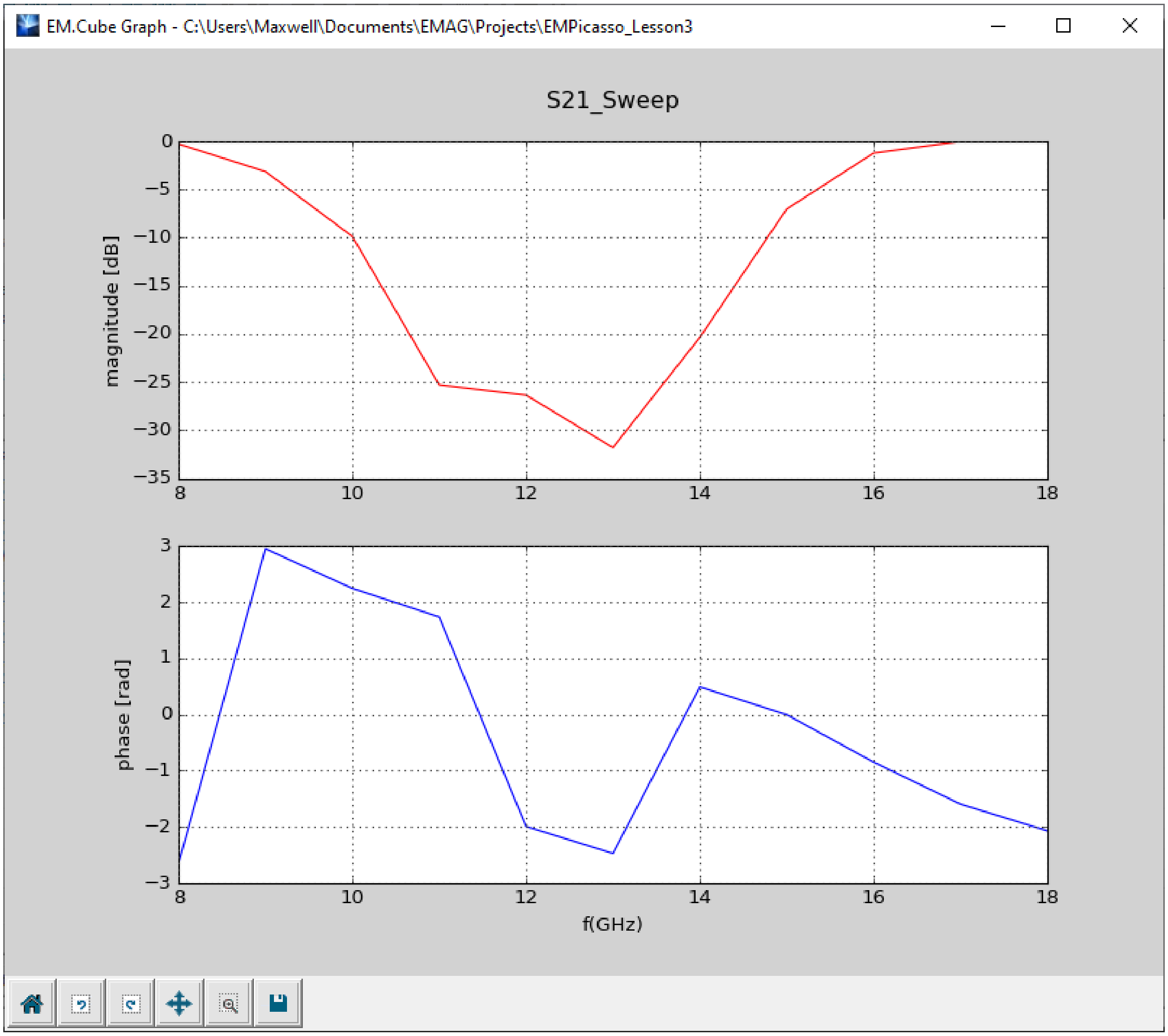


Figure 11. *The plot of S_{21} parameter of the microstrip filter structure.*

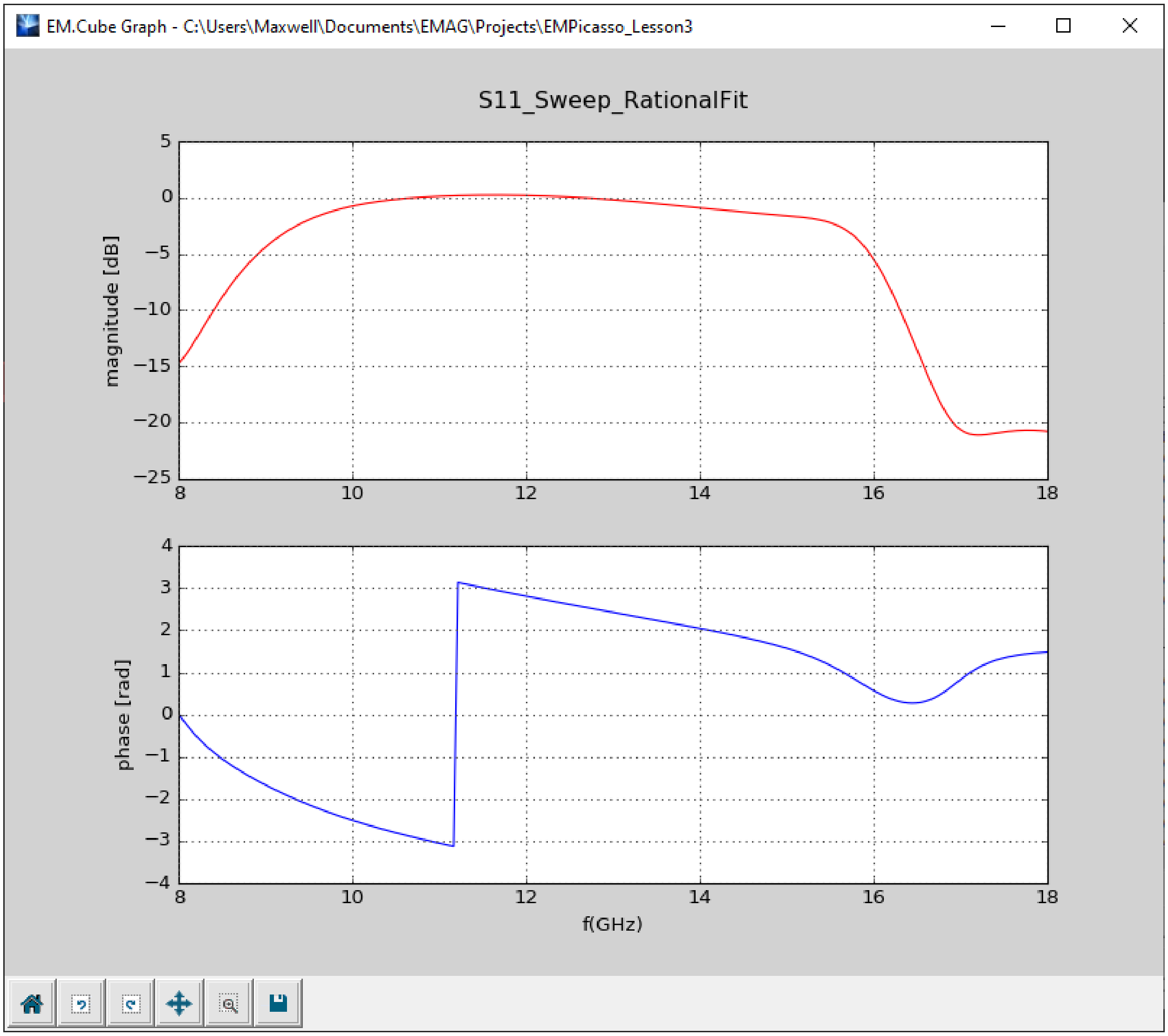


Figure 12. *The plot of rational fitted S_{11} parameter of the microstrip filter structure.*

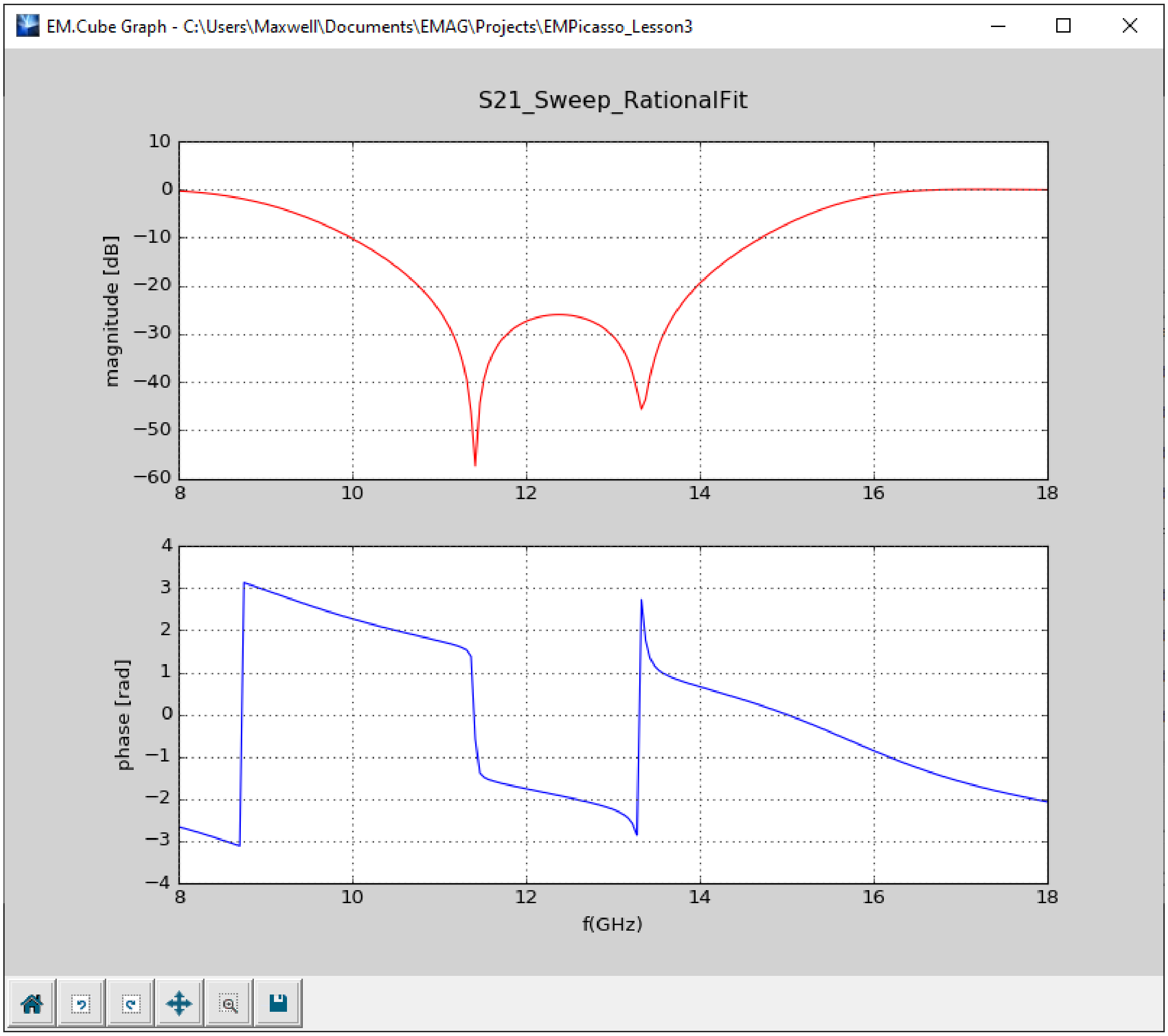


Figure 13. *The plot of rational fitted S_{21} parameter of the microstrip filter structure.*