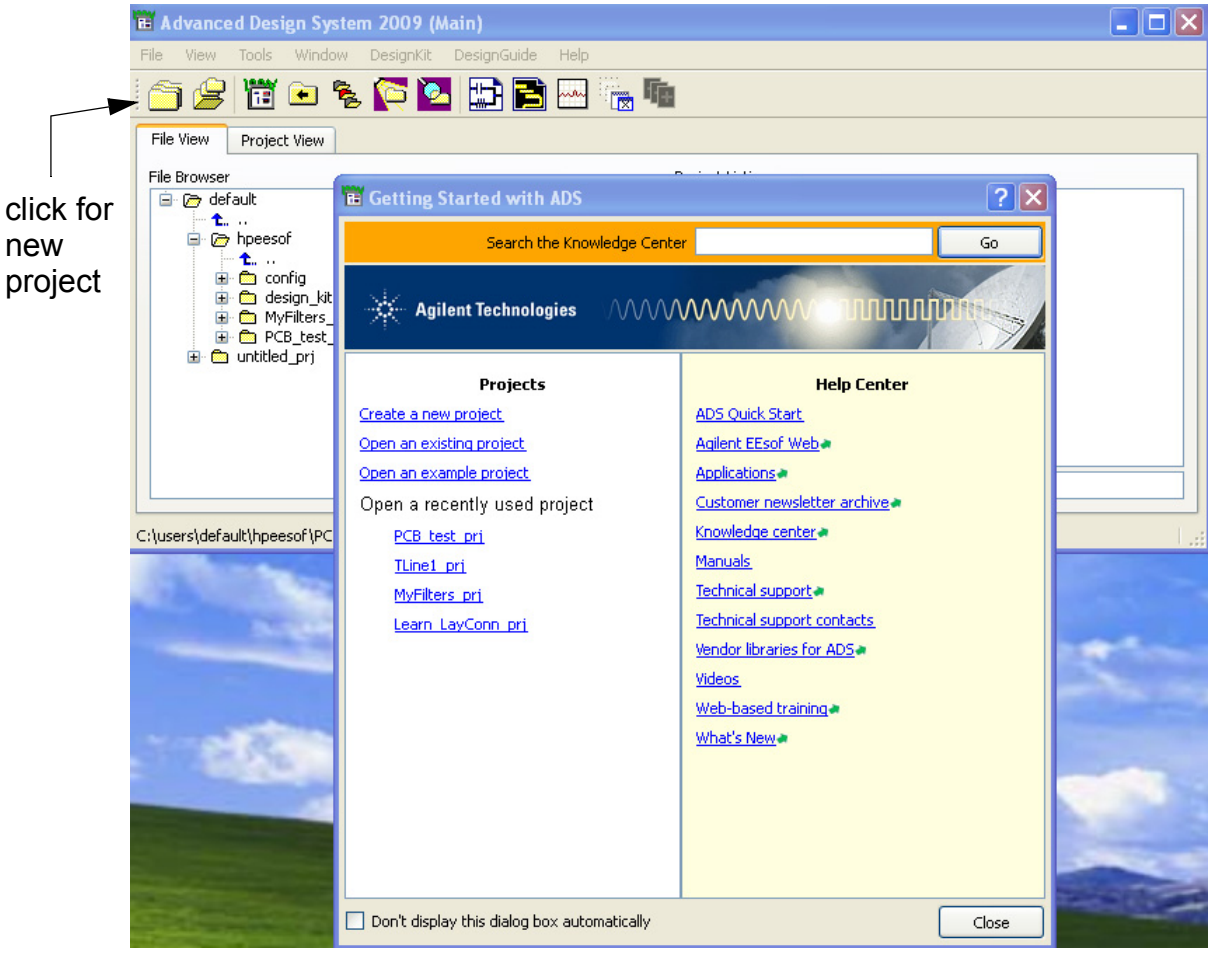
First Steps with ADS and Coax Modeling

ADS Session 1

Start ADS and Create an Empty Project

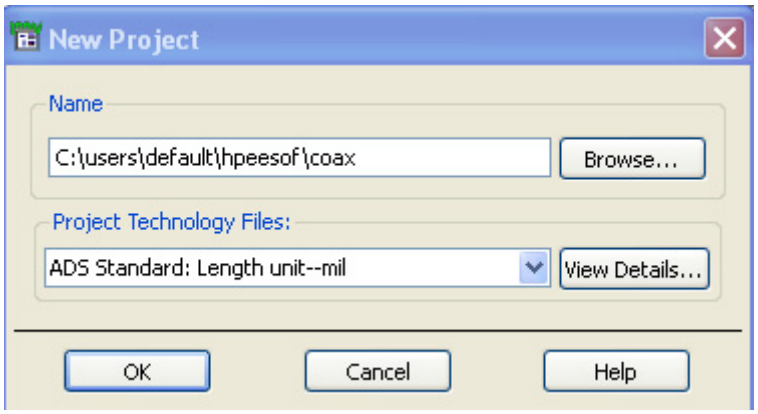
- Look for a desktop icon or start menu item entitled Advanced Design System 2009
- ADS will start up and you will see ultimately:



- Close the getting started with ADS dialog box, and create a new project by clicking on the indicated button bar 'folder

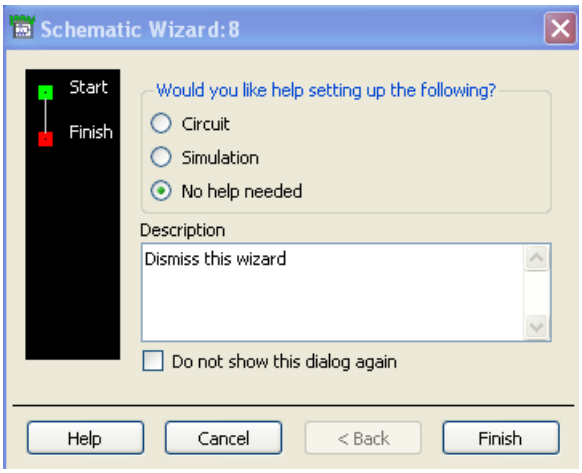
icon’

- Give the project a name and note where it is being placed so you can find it again later

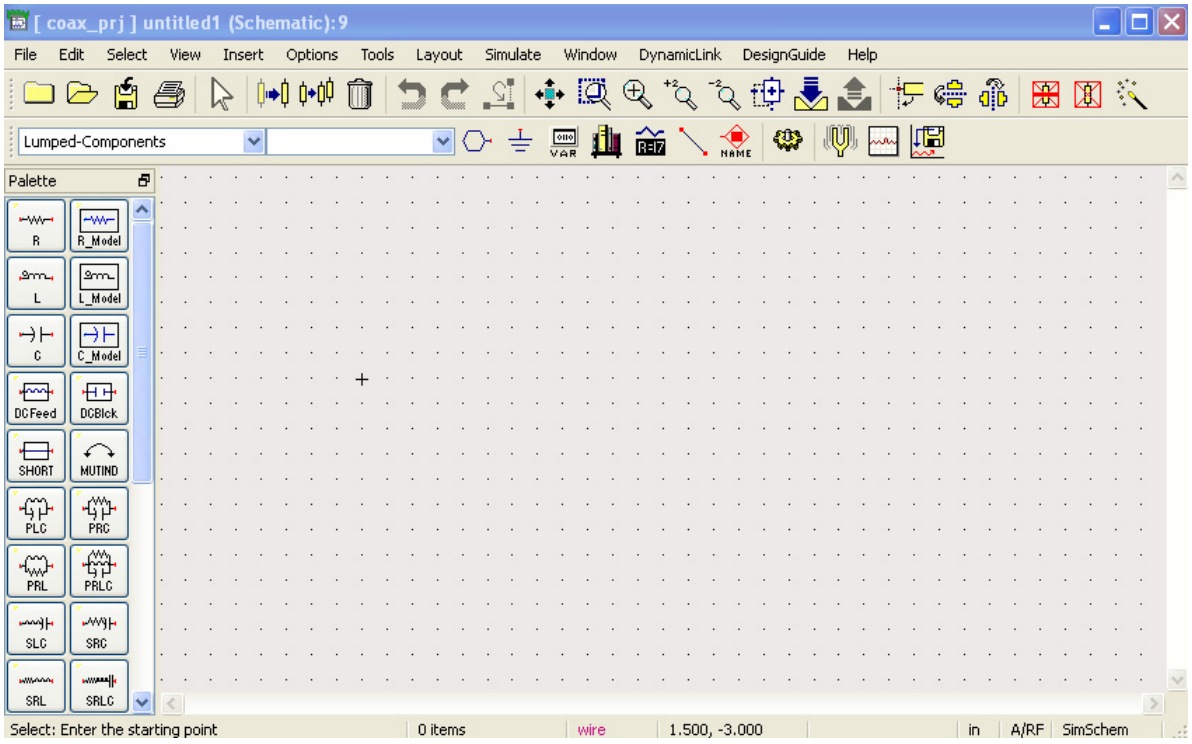


  - ADS creates a folder structure for each project
  - Each project holds a variety of file types placed in the sub-folders accordingly
  - For example, you can have many schematic files, plot files, and layout files all within a single project
- If a project was already open, ADS will ask you save it and then close it (As far as I know, you can only have one project open at a time)

- Next you will see a Schematic Wizard, which for choose *No help needed* and move on

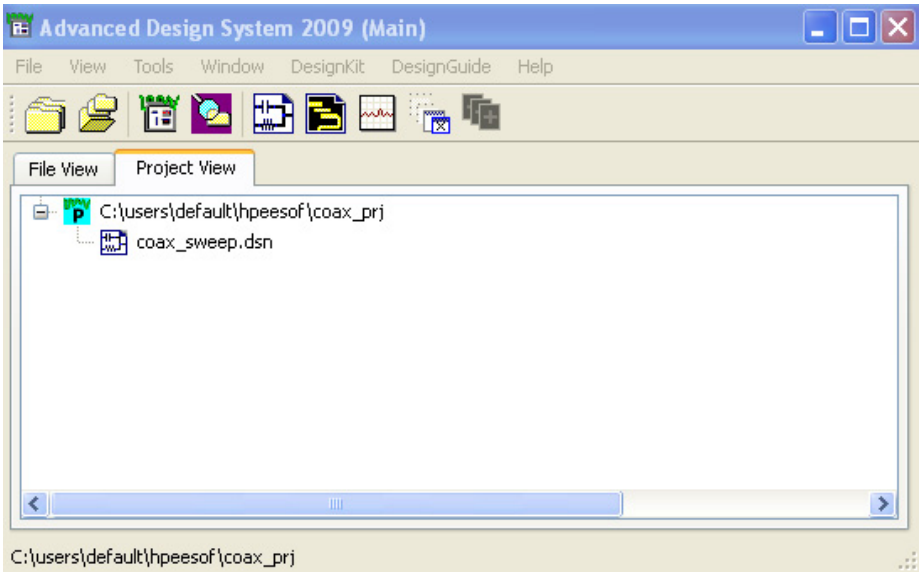


- An empty schematic window will open, and it will be untitled to start with



- Give this empty schematic a name, e.g., `coax_sweep` by clicking on the floppy disk button bar icon (a .dsn file)
  - If you were to go look at the ADS project view dialog now,

you would see that there is a saved schematic file in the project



– In the future you can open this particular schematic, once the project is open, by double-clicking this item from the Project View

- We will use this schematic to set up a very basic two-port *s-parameter* frequency sweep
- Before doing this we will investigate the transmission line modeling tool *LineCalc*, which is available from the Tools menu when a schematic window is open

Working with LineCalc

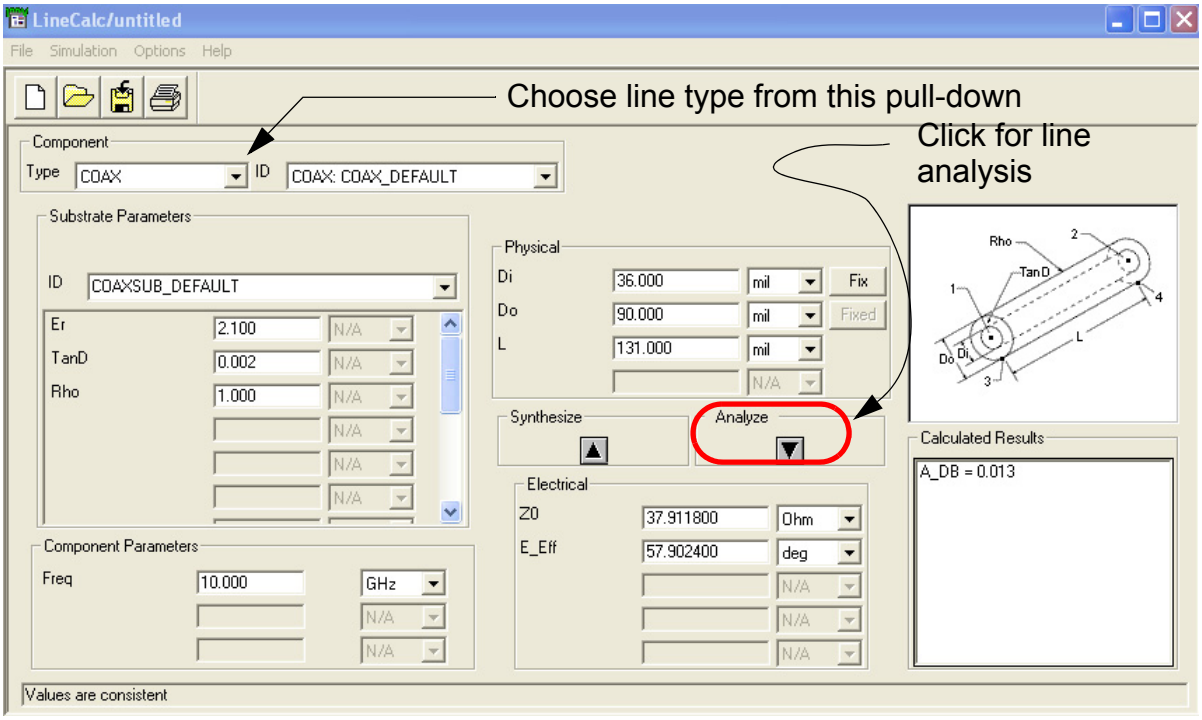
- Go to the Tools menu, click LineCalc, and from the flyout menu click 'Start LineCalc'
- When LineCalc starts two new windows will open: LineCalc

itself, and a window which contains *simulation/synthesis messages* and *status/summary messages*

– This second wind will keep getting updates as have LineCalc do calculations and when you have simulations run from schematics and other forms of analysis, i.e., planar and 3D EM field simulations, etc.

- LineCalc is a support tool which you will use frequently when creating schematics and layouts of microwave circuits

– Using it for planar transmission lines will be taken up late, for now choose coax from the Component Type pull down



- Now you can make parameter entries into the window for the type of coax you wish to analyze
- LineCalc does both analysis and synthesis

  - **Analysis** obtains the electrical characteristics of the line, characteristic impedance Z_0 and the effective electrical length of the line at the chosen operating frequency, $\theta_{\text{eff}} = E_{\text{eff}}$ (i.e., a quarter wavelength line has electrical length of 90°), from the physical parameters
  - **Synthesis** works in the opposite direction, giving you physical quantities from the electrical parameters
- Note that for coax, the dimensions are given as diameter, not radius
- Also note that Rho, under substrate parameters, is not the conductor resistivity, but rather a scale factor associated with copper (CU), i.e., `Rho = 1.0` means CU as found in coax cable)
- With the default values entered and clicking the Analyze button, we find that the line electrical characteristics are:

$$\begin{aligned} Z_0 &= 37.9118 \text{ Ohms} \\ E_{\text{eff}} &= 57.902° \\ A_{\text{dB}} &= 0.013 \text{ dB} \end{aligned} \tag{1.1}$$

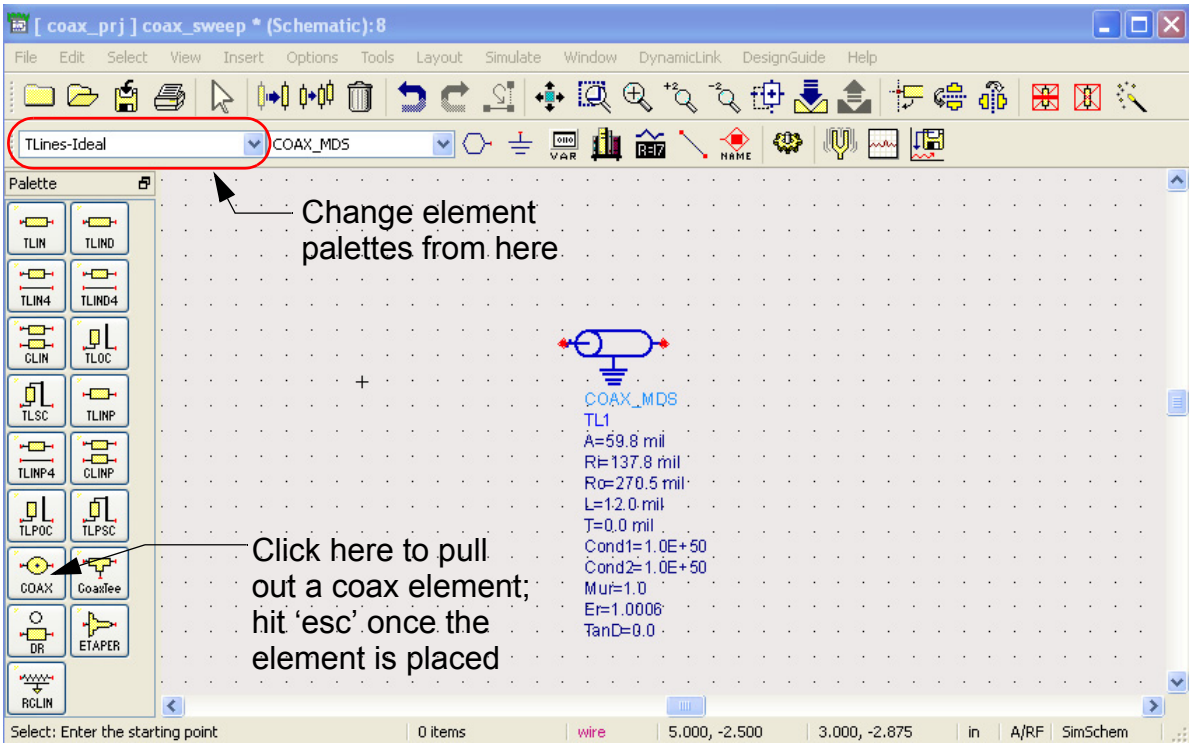
  where A_{dB} is the attenuation or loss associated with a line having physical length 131 mils
- Let us now use LineCalc to synthesize a coax geometry that we can use in a simple design
  - Leave the substrate parameters at the default setting and choose $Z_0 = 50$ and $E_{\text{eff}} = 90°$ at 1 GHz

– Constrain inner diameter to 10 mil and click Synthesize gives

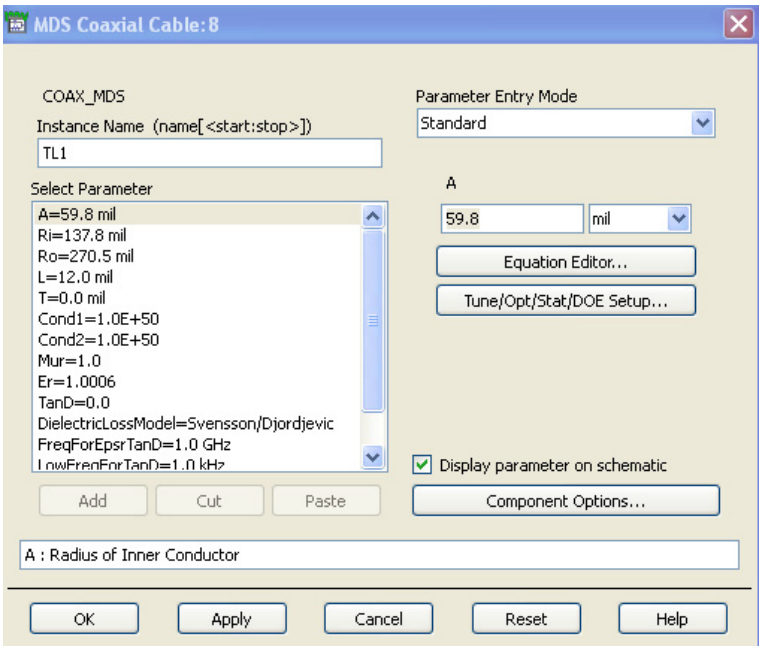
$$\begin{aligned} D_o &= 33.48 \text{ mils} \\ L &= 203.62 \text{ mils} \end{aligned} \tag{1.2}$$

S-Parameter Sweep

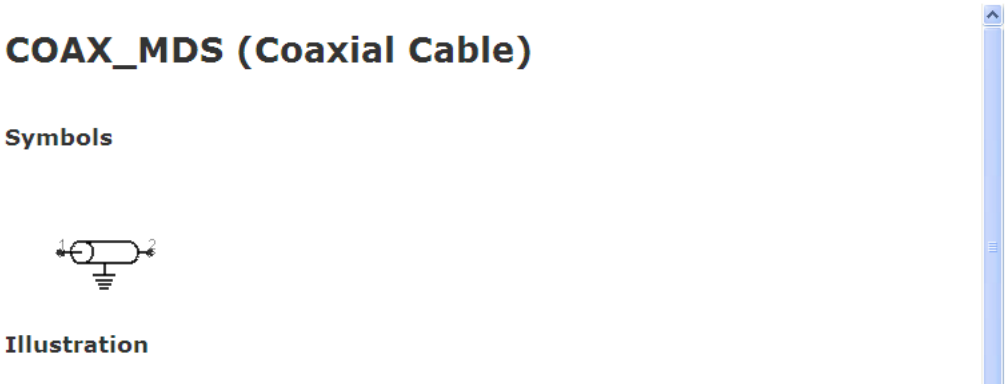
- We will now design a very simple microwave circuit that contains a single transmission line element, one section of coax terminated in 50 Ohms
- Begin by either closing the LineCalc window or simply bring the schematic window to the front
- On this schematic you will begin by entering a coax element, which can be found from the TLines-Ideal element palette

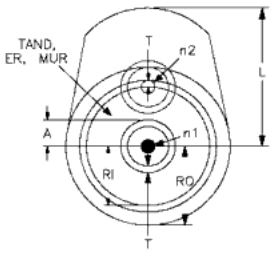


- With element placed you can now set up the parameters for the element directly in the schematic, or with more detail by double-clicking the element to bring up its dialog window



- To get more details on how the coax element is configured, click the help button
- There are a lot of parameters to set for this component as seen from the help system screen capture below:





Available in ADS

Parameters

Name	Description	Units	Default
A	Radius of inner conductor	mil	59.8
Ri	Inner radius of outer conductor	mil	137.8
Ro	Outer radius of outer conductor	mil	270.5
L	Length	mil	12.0
T	Plating thickness	mil	0.0
Cond1	Plating metal conductivity	S/m	1.0e+50
Cond2	Base metal conductivity	S/m	1.0e+50
Mur	Relative permeability of dielectric	None	1.0
Er	Dielectric constant of dielectric between inner and outer conductors	None	1.0006
TanD	Dielectric loss tangent	None	0.0
DielectricLossModel	Model for calculating dielectric loss: 0=frequency independent (traditional), 1=Svensson/Djordjevic	None	1
FreqForEpsrTanD	Frequency at which Er and TanD are specified	Hz	1.0e9
LowFreqForTanD	Low roll-off frequency for TanD (Svensson/Djordjevic model)	Hz	1.0e3
HighFreqForTanD	High roll-off frequency for TanD (Svensson/Djordjevic model)	Hz	1.0e12

Range of Usage

A > T, < RI
Ri > A, < (Ro -T)
Ro > (Ri+T)
Cond1 > 0
Cond2 > 0

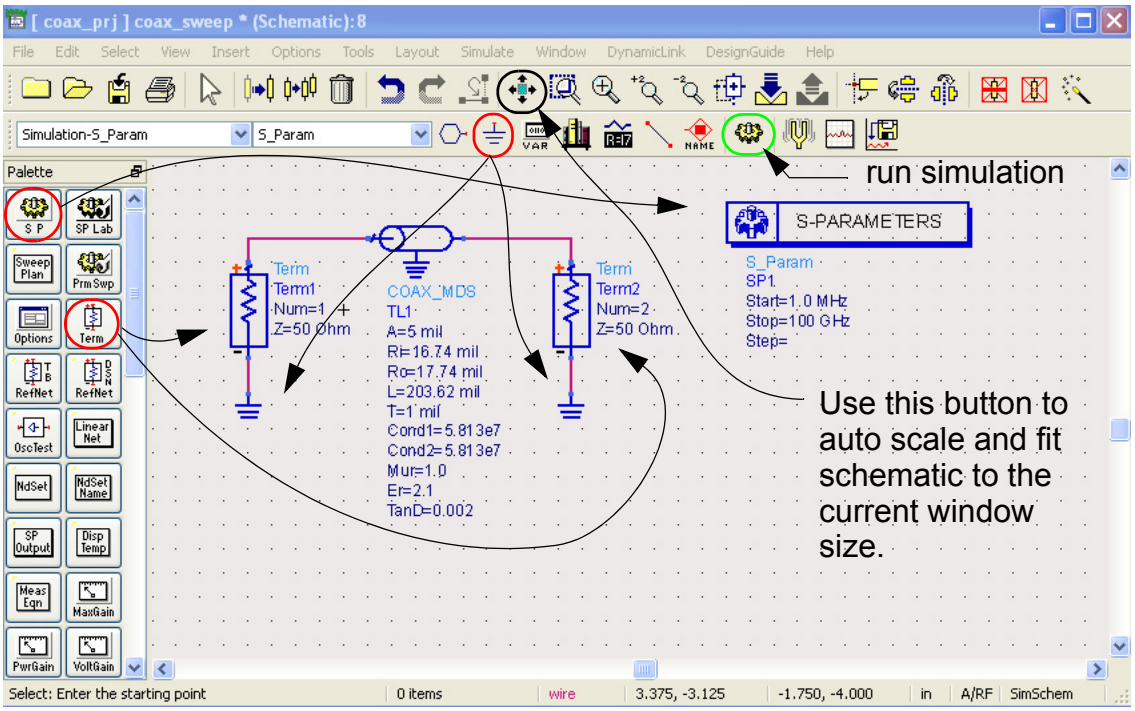
Note/Equations

.. Conductor radius A and inner radius RI are both after plating. If plating thickness T is changed, these values must be changed also.
:. Plating thickness T ≤ A and ≤ (RO - RI).
:. Traditional modeling of dielectric losses with frequency independent permittivity is one of the sources of non-causal simulation results. The parameters DielectricLossModel, FreqForEpsrTanD, LowFreqForTanD, and HighFreqForTanD facilitate causal modeling of substrate dielectric losses. If the values of both DielectricLossModel and TanD are greater than zero then the real and the imaginary parts of the complex permittivity are frequency dependent. For further details see About Dielectric Loss Models

- We will choose defaults for many of the parameters
- For the inner and outer metal conductivity, we choose from Pozar Appendix F: $\sigma = 5.813\times10^{7}$ S/m
- We set ε_r and the loss tangent to match the LineCalc values

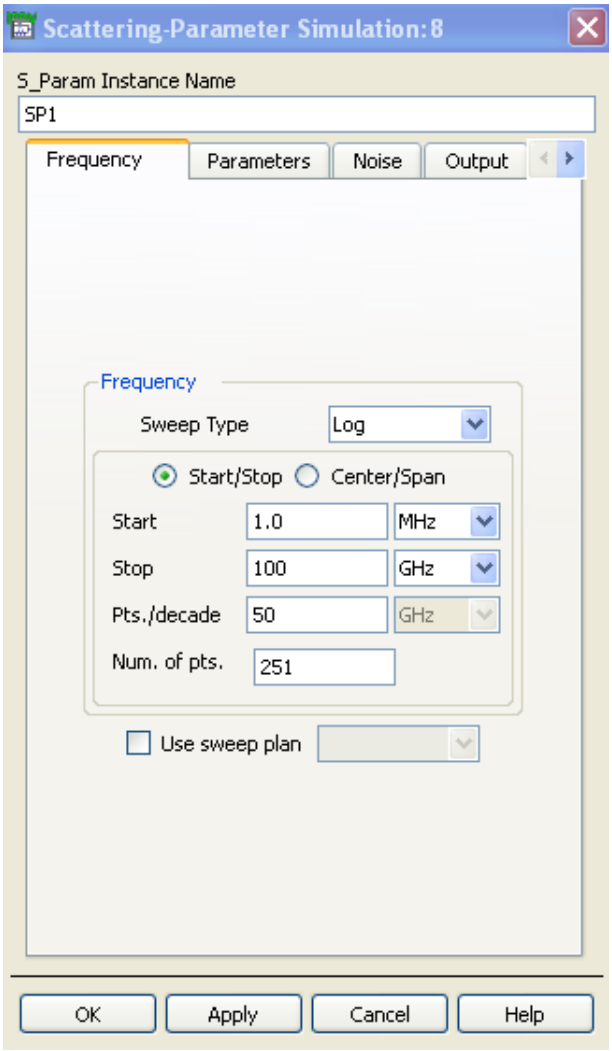
of 2.1 and 0.002 respectively

- We need to set a metal thickness, here we will choose 1 mil
- Next we need to set the inner conductor radius $A = 10/2 = 5\,\text{mil}$, the inner outer radius to $R_i = 33.48/2 = 16.74\,\text{mil}$, the outer radius to $R_o = R_i + T = 16.74 + 1 = 17.74\,\text{mil}$, and the line length to $L = 203.62\,\text{mil}$
- Next we need to place terminations on either end of the coax element and finally place an *s-parameter controller* on the schematic
- Both of these elements are available in the Simulation-S_Param palette



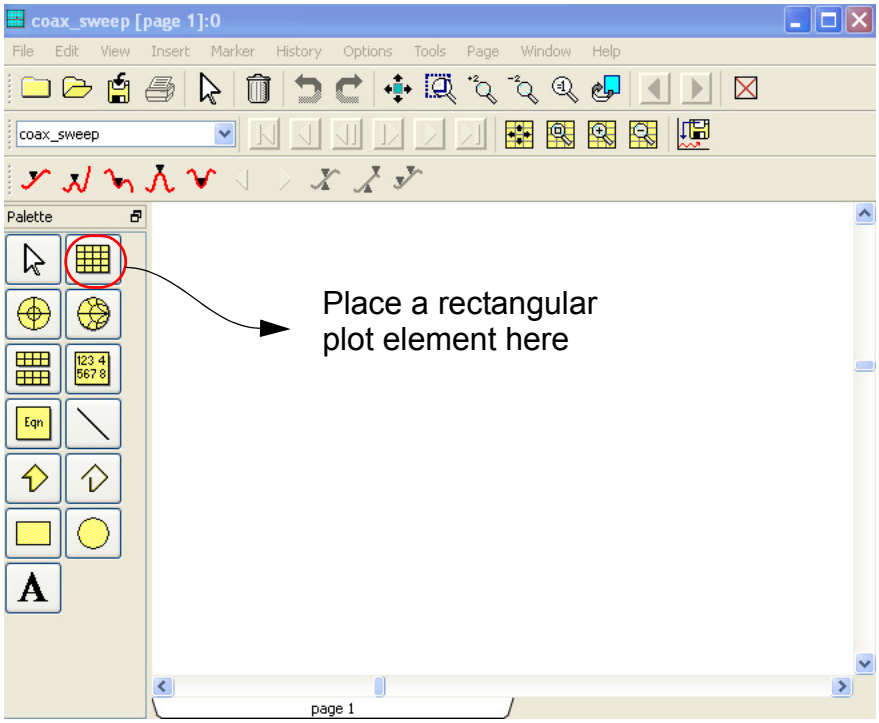
- Note that we have brought onto the schematic two temina-tions, two grounds, and an S-Parameter controller block

- You can add wires to the schematic by clicking on the wire button or using crl-w (always use `esc` to escape from a particular place or edit mode)
- The last step in the schematic is to configure the S-Parameter controller

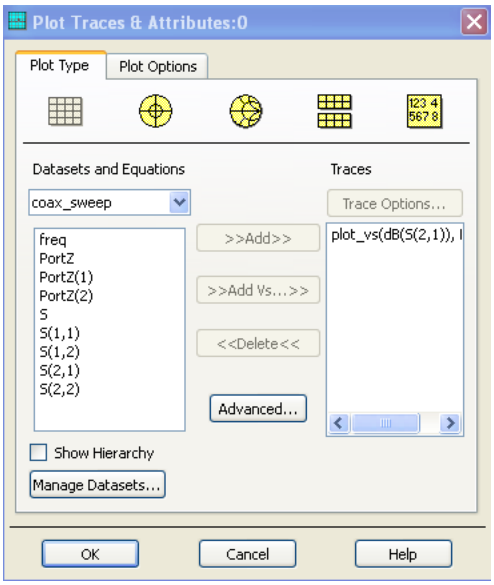


  - Here I have set up a log sweep from 1 MHz to 100 GHz with 50 points per decade
  - New we can run the simulation by clicking the ‘gear’ shaped button

- If all goes well, that is no error messages, a plot window will open



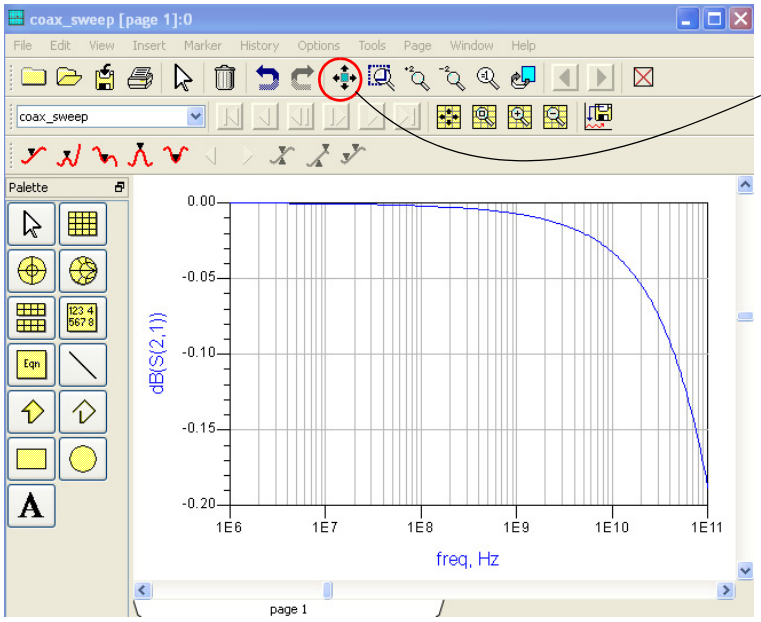
- You now place a rectangular plot element on the plot window and configure it as shown below



  - You want to plot S(2,1) in dB versus frequency

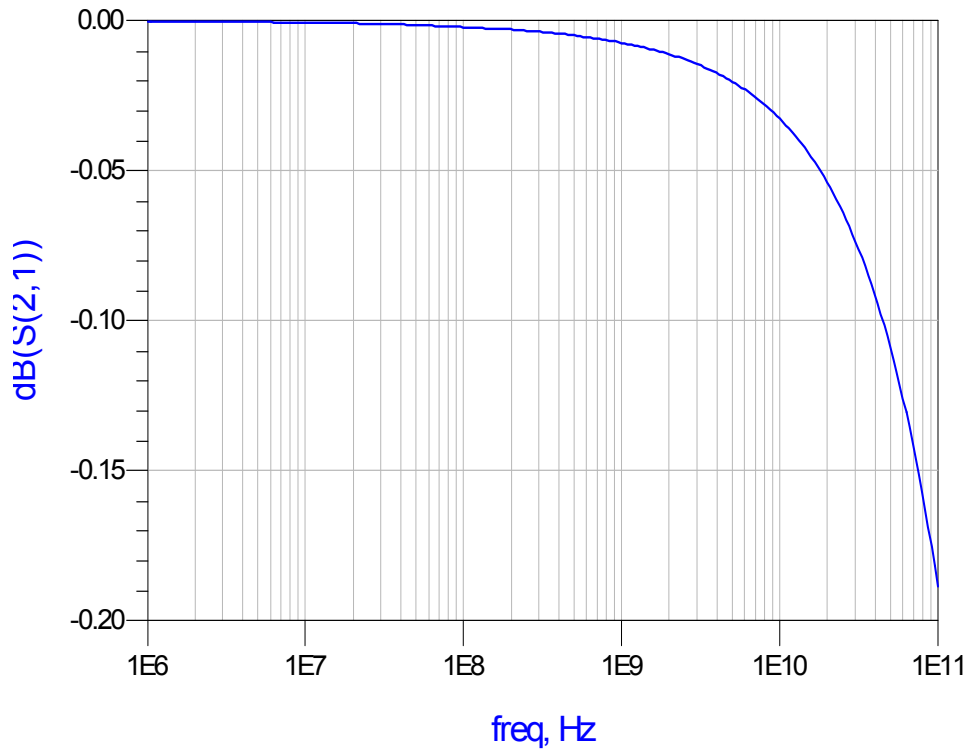
– You can later configure the plot by double-clicking on the plot element to make the x-axis log and change scales, colors, etc, etc...

- The final result is shown below as a screen capture, and then as a plot cut and pasted into this document



Used to fit plots on plot page into the current window size (just like the schematic)

Cut and paste into document



- You should save your plot window and will be saved into the project along with the schematic (a .dds file in project)
- If you run the simulation again, with different settigs, the plot window update
- Each page of a plot window can contain multiple plots of various types, and each plot window can contain multiple tabbed pages, (wow!)
- You can put markers on your plots similar to the way markers work on spectrum and network analyzers in the lab

Summary

- We have just scratched the surface of ADS at this point
- There are 13 total contoller blocks available for runniing simulations
- There is a 2.5D and a 3D EM simulator
- There is a layout editor and more...
- Stay tuned for more