Fit_Model_To_Measured

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Design Notes

Example Modeling Technique Demonstrated with Transmission Line Modeling

This Microwave Office project demonstrates one technique that can be used to fit a model to measured data. The project shows what sort of setup can be done and how Microwave Office can be used to determine model parameters. The project also shows one way to use lumped elements to model tranmission line.

Overview

When modeling measured data, the best way to know if your model is good is to look at the difference between the measured data and the model. If this difference, is 0 then the model is good. This idea will be used to demonstrate a modeling technique in Microwave Office using an example. The example is a single LC section to model a short piece of transmission line. The distributed transmission line model is assumed to be the measured data. Since the transmission line is ideal and electrically small (~= 1/20 of a wavelength), a single LC section can be used to model the line.

Distributed line schematic

This schematic has an ideal transmission line in model that has a characteristic impedance of 10 ohms. It is set to be 1/20 of a wavelength (18 degrees) at 30 GHz. This is assumed to be the measured data for this example

Lumped model schematic

This schematic has the lumped element model for the transmission line. Since the transmission line is ideal (no loss), it can be modeled with just Ls and Cs. The capacitor and inductor values are assigned to variables that are set to be tuned and optimized. To see these settings, select one of the variables, right click, and select **Properties…**

Model graph

 This graph is plotting the difference between the two networks in this schematic in dB. This measurement will be used for optimization. A very large negative number in dB will mean a match between the two networks.

S11 graph

 This graph is plotting S11 of both networks on a smith chart. Used for a visual confirmation to see how good the modeling is.

s21 phase

This graph is plotting the phase of s21 of both networks on a rectangular graph. Used for a visual confirmation to see how good the modeling is.

Modeling Exercise

Originally, the capacitance and inductance in the "Lumped model" schematic are set to 0.5 nH and 0.5 pF. These values are set by the variables **c** and **l** in schematic. These variables are setup for tuning, optimization and have set constraints.

With the "Model" graph the top graph, turn on the tuning. Select **Simulate > Tune** from the menus or select the **Tune** button from the main toolbar. Adjust the value of l and c to get the trace on the "Model" graph to go down. If you get just the right values, the response will be very low. However, this is hard to do with the tuner. The c and l values were purposely set extremely big for this simulation.

Now, try the optimizer. Select **Simulate > Optimize** from the menus. Leave the default settings and hit **Start**. After about 500 iterations the optimization should stop. The trace on the "Model" graph should be below the optimization goal. Now look at the "s11" and the "s21 phase" graphs to see that the two responses are identical. Now, the c value should be approximately 0.084 and the l value should be 0.0163.
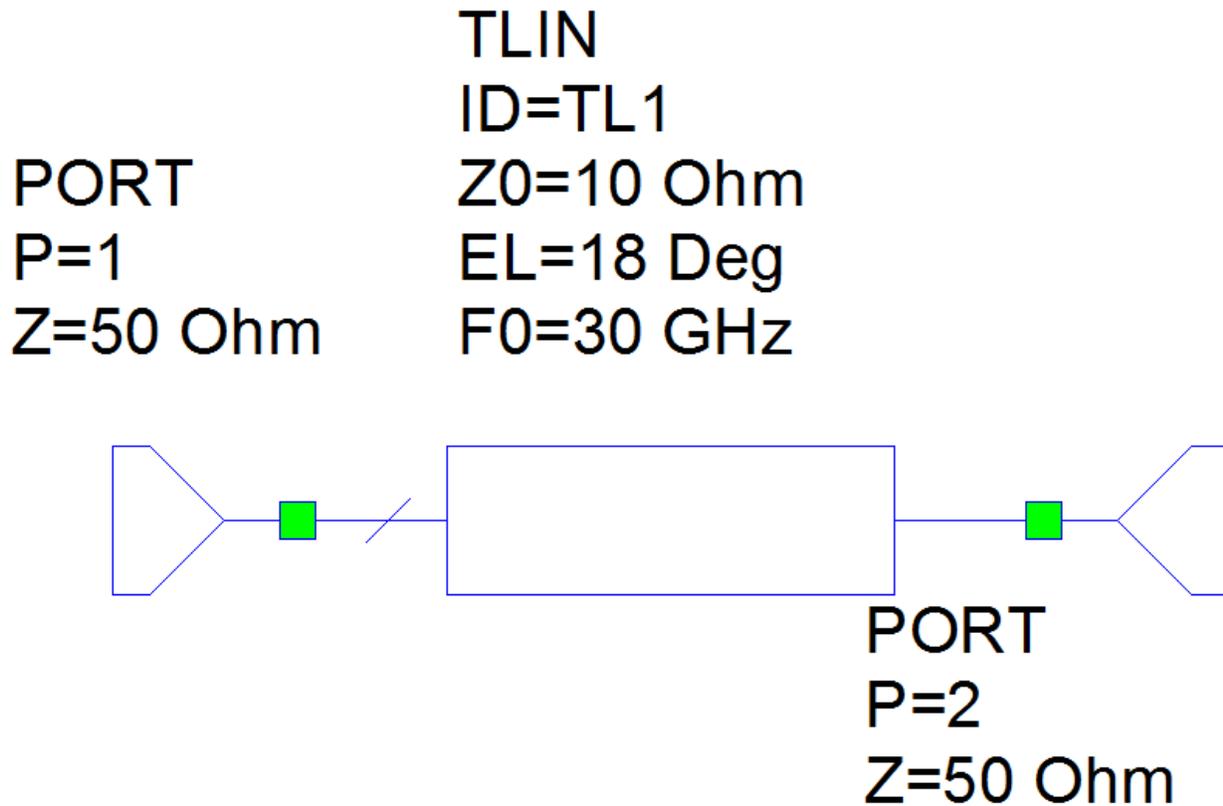
The lumped model is now very close to the distributed model.

This simple technique can be used to study the changes of capacitance per unit length and inductance per unit length for different transmission line impedances.
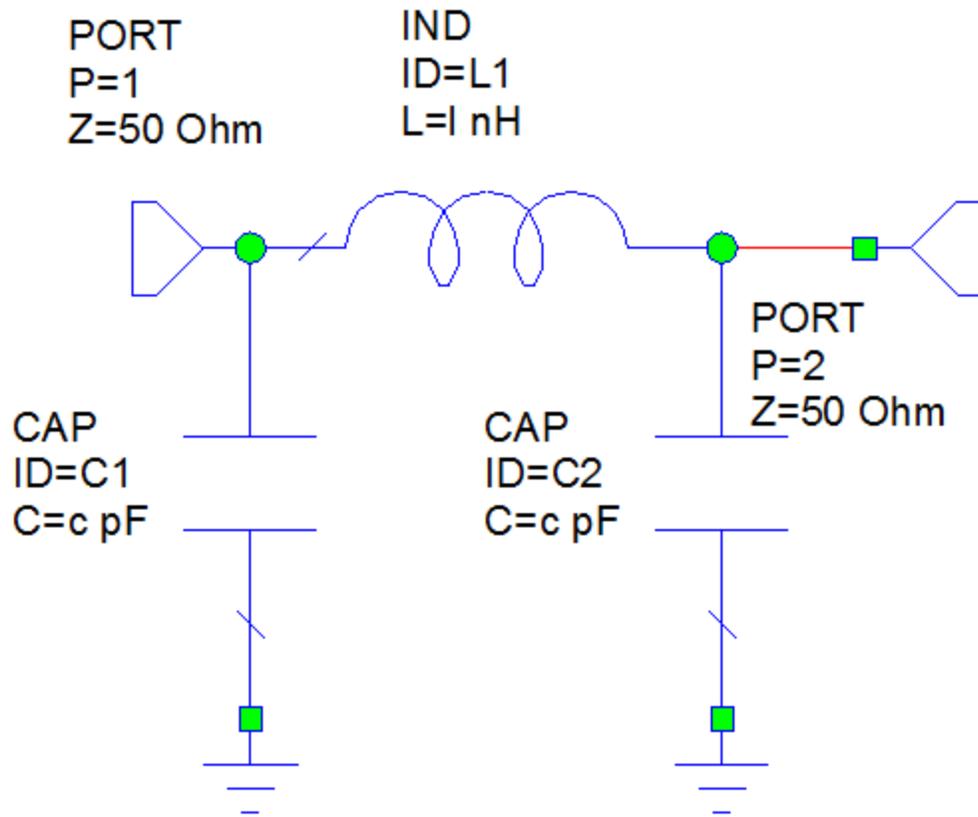
Advanced Study

The technique shown above will work well for electrically short structures (approximately 1/20 of a wavelength or less). See what happens if you change the EL parameter line of the "Distributed line" schematic to 90. Try optimizing again to see if you can get a single section LC to match this model. You won't be able to get a good match. This means you will need more LC sections to accurately model the line. To demonstrate, reset the l and c values to their original values. Now make a new schematic and bring in the lumped model schematic as a subcircuit and cascade 5 of these subcircuits. Now add a measurement to the "s21 phase" graph for the new schematic you created and plot the phase of s21. Notice that they will be identical to the distributed model with the electrical length set to 90 degrees.
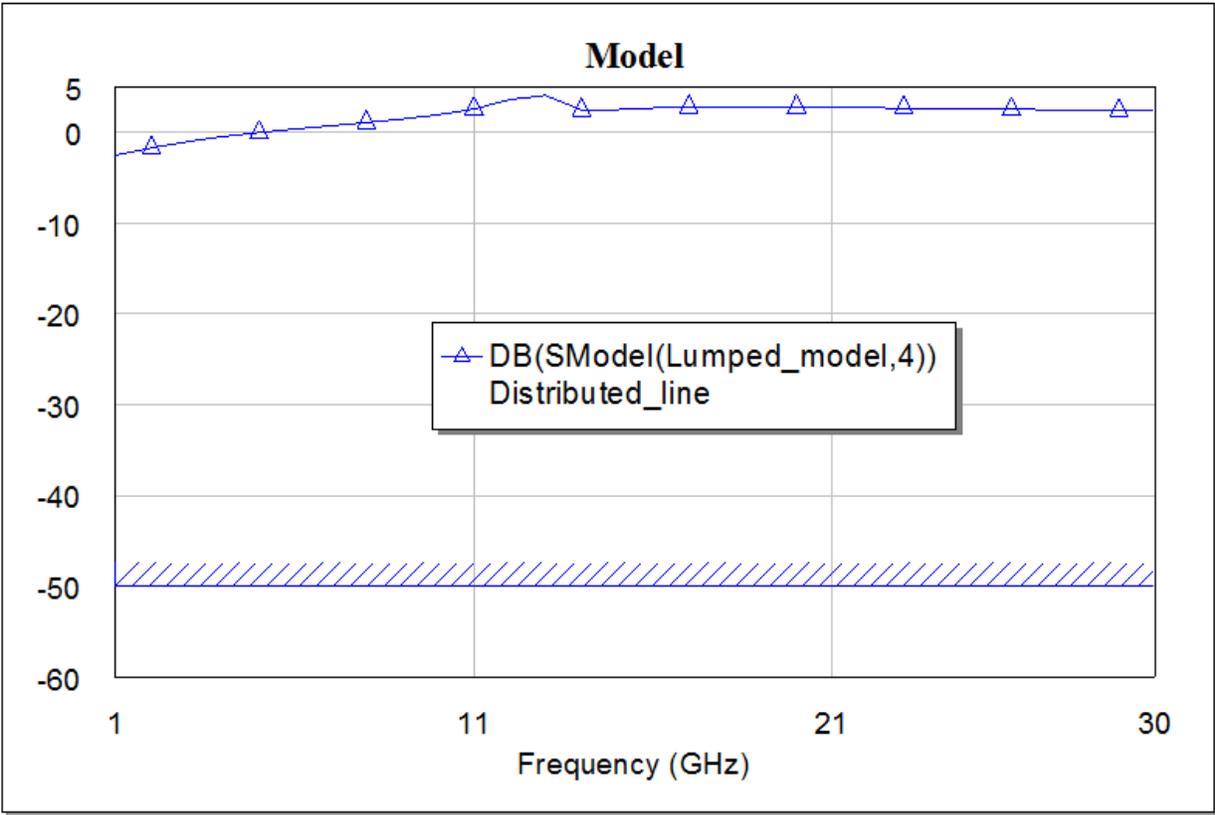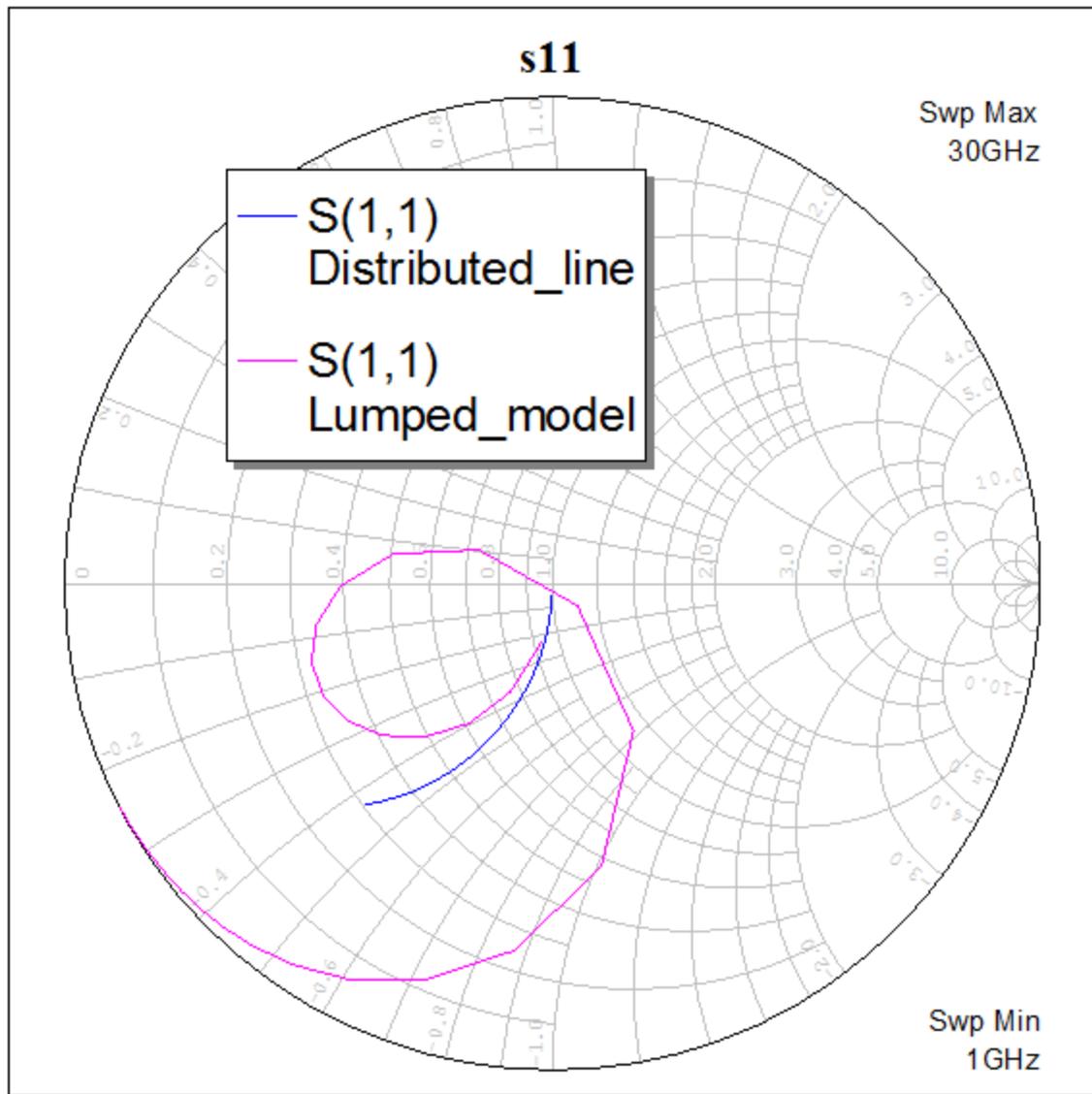
Schematic - Distributed_line

TLIN
ID=TL1
Z0=10 Ohm
EL=18 Deg
F0=30 GHz

PORT
P=1
Z=50 Ohm

PORT
P=2
Z=50 Ohm

Schematic - Lumped_model

c=0.5
l=0.5

PORT
P=1
Z=50 Ohm

IND
ID=L1
L=l nH

PORT
P=2
Z=50 Ohm

CAP
ID=C1
C=c pF

CAP
ID=C2
C=c pF

Graph - Model

Graph - s11

s11

Swp Max
30GHz

S(1,1)
Distributed_line

S(1,1)
Lumped_model

Swp Min
1GHz

Graph - s21 phase

s21 phase