Lab 3: Couplers and Power Dividers

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Objective:

- Design, optimize, build, and test a 3 dB power divider

Equipment:

- Agilent 8510C Microwave Vector Network Analyzer
- TRL Calibration Kit

Procedure:

1. Review the text or your portfolio and find the desired parameters for a 3-dB coupler using microstrip line. The coupler should divide the power evenly (3 dB) between the two output branches. It will operate at a frequency of 2.5 GHz. Each student in the class should do his or her own design for this lab and test it in Libra. Your group will then decide which design to mill and test.

2. Use ports, lines, tees and bends as desired in Libra to implement your design.

   A. Design your 3dB power splitter as described in the text. Use MLIN and MTEE to produce it in the schematic.

   B. Design quarter-wave matching sections for the output ports:

   Use Linecalc to find the lengths and width for the quarter-wave transformers of the output sections (which are no longer 50 ohms lines). Also make sure that the widths of the tee correspond to the widths of the line. These widths can be verified using the Design Synchronization and looking at the layout to see if the widths look correct.

   C. Add lengths of line to the input and output ports to allow accurate calibration:

   There are some important specifications that you will need to conform to so that you will be able to get accurate results when testing the circuit. Since the TRL calibration of the network analyzer is calibrated to 1.9304 cm (760 mils= 1/2 of the length of the THRU), you will want to append at least that length of line (with Zo = 50 ohms at 2.5 GHz) to the input and the outputs of the circuit. The width necessary for the 50 ohm impedance can be found by using Linecalc.

   D. Adjust the distance between the output ports so that it can be held in the circuit board holder:

   When using this circuit with the test holder, the output lines need to have 2.54 cm (1000 mil) centers. Make sure that your circuit conforms to this separation so that you can match one output port while finding the S-parameters for the other port using the network analyzer.

   E. The total length of the circuit should not exceed 6.096 cm (2400 mils). This is the maximum amount the test holder can be opened while still being able to place a circuit inside of it.

   F. Save the circuit and test it on the test bench in Libra. Note: this is a multi-port network and has nine S-parameters describing its operation. Decide which parameters are important for your design and prepare to plot them from 2-3 GHz using the values for i and j that you have chosen. This is done by choosing Select Palette, Network Parameters, and Sij. Set the values of i and j as necessary.

G. Analyze the circuit and plot it. To see all of the parameters, select Edit, Measurements, and then cut and paste as desired to plot the parameters. It may be best to view one parameter at a time to get a good view of the response. Another way to get a good idea of the actual value of the response at a particular frequency is by using View, Cursor and then moving the cross-hairs to the proper frequency to find its value.

H. Optimize the quarter wave transformers:

Use the tune button next to the plot button to adjust the lengths or widths of the quarter-wave transformer sections. After clicking on the tune button, click on the component that you would like to change and then adjust parameters. After tuning the first time, each modification results in a new plot with a different color. As a result, you can check to see if a better response is attained.

I. When you are satisfied with the response of the circuit, double check to see that the parameters in parts A-D above are met and Synchronize the schematic.

J. Follow the steps for exporting the file to the HPGL format as described in the handout for exporting files in Libra

(or see http://www.engineering.usu.edu/ece/faculty/furse/TUTORIAL/libra/circuitcam.html)

K. Save your data from libra on a disk so that you can compare it with the network analyzer plots: On the graph window, click Graph - New - Table, and the data will appear on a table. Use Edit - Measurements (Add) to put all of the data you want in the table. Cut and paste it to a text file for future use. An easy way to do this is to put the cursor before the first frequency. Hold down CTRL - SHFT - END (there is an END key), and this will highlight the whole document. Open a text editor, and press the middle mouse button to paste. Place a variable name at the top with a square brace (a = [ ) and place a closing square brace at the end of the document. Save the file as file_name.m. When you are ready to use it in Matlab, get in the directory where you saved the file and type: >> file_name. In this case the data will all be stored in the variable "a." You can then use the variable a to make plots or calculations as desired.

L. Your group will turn in the disk with the file to be milled along with the sketch and dimensions of the circuit so that it can be milled. Make sure that the disk and sketch are well labeled. Your group will test the circuit on the Network Analyzer after Spring Break.

Measure your circuit:

1. Attach the circuit board holder to the network analyzer and perform a TRL calibration.

2. Attach your circuit to the holder.

3. View the different parameters on the Network analyzer. Make sure that you match the output port(s) that you are not measuring.

4. Plot your network analyzer results against your libra results on the same graph. See the tutorials on the web for network analyzer data plotting.

5. Also measure the 20 dB coupler provided.

6. Draw conclusions: How well matched are all of your ports? Was the power divided as expected? What losses were observed? (Where did this power go?) Was the power divided as expected for the 20 dB coupler?