UNIVERSITY OF UTAH
ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

ECE 5320/6322 LABORATORY #1 Fall 2014

USING AGILENT ADS (ADVANCED DEVELOPMENT SYSTEM) AND THE HP 8720 NETWORK ANALYZER

Introduction:

ADS is Agilent's latest integrated system of software applications for analysis and design of microwave circuits. ADS contains the latest state-of-the-art computer programs required for sophisticated design work.

During this semester, we will learn how to use a portion of the software tools that analyze linear, passive microstrip circuits, and make swept plots of the reflection and transmission versus frequency. You will also learn how to use the layout tools which are used for milling of the design. You can also use the additional tools to analyze active circuits which contain transistors and diodes. Models of all these elements are contained in ADS, and circuits composed of these elements can be assembled by simple "drag & drop" operations on the GUI interface.

We worry about making the analysis & design process so easy that you (the student) fail to learn the underlying scientific principles and physical processes related to our subject. Our philosophy in ECE 5320/6322 will be that hand (or MATLAB) calculations in the beginning using the underlying theory followed by ADS analysis of the same (or similar) circuits will suffice to ground students in the underlying principles. Beyond this, it is up to you to make sure that you do not misuse these tools by trusting them too much and thinking too little about the results you obtain. **Always try to understand your analysis outputs in terms of the physical properties of the circuit elements.** As the frequency sweeps, make sure that you understand the <u>behavior</u> versus frequency and any <u>resonant points</u> where reflection or transmission peaks occur. This will help you learn microwave engineering while also learning how to use the professional tools you will see on the job.

The HP 8720 Network Analyzers (NA) used in the labs were donated by Agilent/Hewlett-Packard. These state-of-the-art instruments are of the type that you will see on the job in a microwave company, and you need to spend as much time as possible learning how they operate. Without these Agilent/HP donations, we would not be able to provide students with this type of "hands-on" training, and we need to be very careful with this equipment.

The most important safety measure in working with the NAs is to avoid electrostatic discharge (ESD) while working at the bench. As we walk, we accumulate charge and when we touch something conductive, this charge drains off as an ESD. We usually do not even feel it until it gets to thousands of volts, but we must always assume that it is possible. Therefore, **NEVER TOUCH THE NETWORK ANALYZER CABLES AND ATTACHMENTS UNLESS YOU WEAR A GROUNDING STRAP!** An ESD into the coaxial input ports can damage the very sensitive microwave receivers in the system. They are very expensive to repair. Other than this, you probably will not hurt anything by pushing buttons and learning what the NA can do. (But, avoid "delete" and "modify" keys.)

Goal:

To learn how to use Agilent ADS to predict the performance of simple microstrip elements and to learn how to use the HP NA to measure the S-parameters for comparison of theory and experiment.

Procedure:

You will be provided with four simple microstrip line circuits to analyze using the ADS software. You will also be provided with calibrated microstrip adapters for the NA so that you can measure the elements and compare the results. An illustration of these circuits and their equivalent models is attached.

The procedure you should use in this lab consists of these steps:

1. Read through the ADS tutorial in the lab supplement the tutorial steps will be used for this lab.

2. Launch a new project in ADS and enter the substrate parameters,

   Properties of RO4350 Microwave Laminate

Dielectric constant	3.48 ('Er' in ADS modeling)
Loss tangent	0.0035 ('TanD' in ADS modeling)
Thickness of the substrate	30 mils ('H' in ADS modeling)
Thickness of the metal layer	1.3 mils ('T' in ADS modeling)

   using the MSUB substrate element under the "T-line Microstrip" category.

3. Input the MLIN elements along with their measured widths and lengths. Use information on the last page of the handout for the dimensions of the sample line.

4. Analyze the S-parameters from 1 to 8 GHz and form plots of amplitude and phase for each parameter. You should plot all of the magnitudes for each parameter on the same graphs and all of the phases on another graph for comparison. Use the dB scales (0 to -50 dB) for the magnitudes and use degrees (-180 to 180) for the phases. <u>Also, be sure to print the responses and your circuit schematic diagram for your report.</u>

5. Make a plot of S11 on a Smith Chart and S21 on a Polar Plot. These alternative outputs provide both magnitude and phase on the same chart.

6. Create new projects for each of the three remaining circuits.

7. Start your work with the NA by using the straight-line element to check NA calibration. Read the supplementary handout for calibration procedures. You will need to learn how to adjust the NA output scale in order to see how well S21 approximates 0 dB and how well S11 approximates -60 dB as it should for a uniform length of line.

8. Document your results for your report to demonstrate that you are getting about what you expect for a simple piece of transmission line and that the NA is calibrated. In all future labs, you should always check calibration by first measuring a piece of straight line. You can then just state in your report that this check was done and what the results were in terms of deviations from ideal.

9. Connect the circuit to the test fixture and capture the measure responses into ADS, plotting the theoretical and measure values together.

10. Measure each of the remaining three elements using the NA and make plots that compare the amplitudes and phases of the parameters against the theory from ADS. Often you will find that the parameters for the second port are essentially the same as the first. If this is true, it is okay to just state this in your lab report and not output the whole set of parameters.

Write-Up

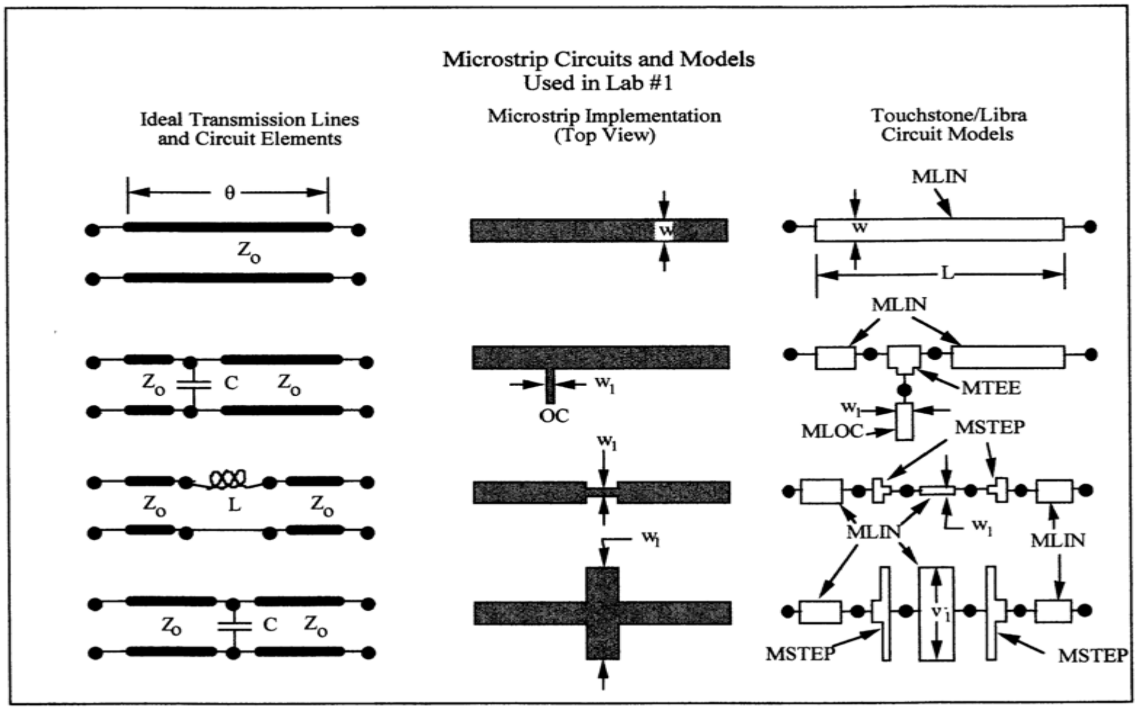
Discuss your step-by-step procedure in sufficient detail so that a peer can follow what you have done and the results you obtained. **Bundles of graphs with no explanations are unacceptable.** You should make hand notations as needed on all graphs to explain the results and identify the curves.

Include graphs of the S-parameters for each of the four circuit elements and use drawings and equations to clearly identify the meaning of each S-parameter in terms of reflection or transmission of the directional signals at the circuit ports (see Pozar's Section 4.3, p. 174 for the definitions of the S-parameters). Also, identify the physical reasons for all trends versus frequency and for any resonance points or anomalies which exist in the data.

At this point, you are free to change your ADS model to better fit the data. Document and explain what you did and why it was necessary. Remember that the goal here is to find out how well we can use ADS to predict actual measured performance. Use your write-up to show how well this process works.

Finish your write-up with a short summary statement about what you have learned and anything you feel is worth recording for future use (including future lab procedures that will help students).

Hole-punch your report and put it in a three-ring binder. After it is organized and documented so that it reads like a report, staple it together in the upper left-hand corner so that it can be turned in for grading. Use a large three-ring binder to store both your lab reports and your homework sets for future reference.



Microstrip circuit dimensions:

All other circuits are a modification of the basic thru line (note: MSTEP has no length, it's just a way to indicate a change in line width to the simulation tool).

Thru line	$w \times L$	=	66.5×2500 mils	
OC stub line	$w_1 \times L_{MLOC}$	=	15.6×364.8 mils	(offset 700 mils)
Series ind. line	$w_1 \times L_{MLIN}$	=	15.6×114 mils	(centered on the line)
Parallel cap. line	$w_1 \times L_{MLIN}$	=	308.7×144.2 mils	(centered on the line)