ELC 5338 High Frequency Electronics I
Laboratory #2: Vector Network Analyzer Measurements

Note: This lab procedure has been adapted from a procedure written by Dr. Larry Dunleavy at the University of South Florida for the WAMI program. With permission of USF, It has been modified for use at Baylor University by Dr. Charles Baylis.

Printed Name:______________________

Lab Partner(s): ____________________________

Please read the reminder on general policies and sign the statement below. Attach this page to your Post-Laboratory report.

General Policies for Completing Laboratory Assignments:

For each laboratory assignment you will also have to complete a Post-Laboratory report. For this report, you are strongly encouraged to collaborate with classmates and discuss the results, but the descriptions and conclusions must be completed individually. You will be graded primarily on the quality of the technical content, <u>not the quantity</u> or style of presentation. Your reports should be neat, accurate and concise (the Summary portion must be less than one page). <u>Laboratory reports are due the week following the laboratory experiment</u>, unless notified otherwise, and should be turned in at the start of the laboratory period. See the syllabus and/or in-class instructions for additional instructions regarding the report format.

This laboratory report represents my own work, completed according to the guidelines described above. I have not improperly used previous semester laboratory reports, or cheated in any other way.

Signed: ___________________________________

ELC 4383 – High Frequency Electronics I
Laboratory 2: Vector Network Analyzer Measurements[1]

Laboratory Assignment:

<u>Setup: The following components will be needed for the lab exercise</u>:

- Two F-F adapters
- Maury Microwave 3.5 mm or other suitable calibration kit with defined standards: open, short, and load
- 2 cables
- 1 3 dB attenuator
- 1 6 dB attenuator
- 1 20 dB attenuator
- 1 short (3 to 6 inch) SMA cable
- Filter

A vector network analyzer will be used to make one- and two-port S-parameter measurements.

<u>Calibration Demonstration</u>: The instructor will demonstrate the performance of a 1-port VNA reflection calibration. A calibration should be performed from the low-frequency end of the VNA to 3 GHz. The following settings should be used: IF Bandwidth = 100 Hz, Number of Points = 401, Averaging Off

<u>Part I: Reflection Measurements</u>

A. <u>SMA Female Short Circuit</u>: Connect the female short circuit to port 1 of the measurement system. Set the plot format to Smith Chart. Place a marker at 3 GHz. Read the real and imaginary parts of the impedance values from the plot. Answer the following questions:

Does the Smith Chart trace follow along the outside edge of the Smith Chart (If no, ask for assistance)?

3 GHz Marker Values (read from Smith Chart format):

Resistance: ______________Ω Reactance:________________________Ω

Equivalent Inductance:__________________________________pH

Change the format and obtain the following readings:

3 GHz Value of the Reflection Coefficient (S11) Phase:___________________________ degrees

Max/Min Ripple in Reflection Magnitude: +/-___________________dB

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[1] Dr. Larry Dunleavy originally developed this laboratory procedure for the University of South Florida WAMI Lab and it was later modified by Dr. Charles Baylis for use at Baylor University.

Save the measurement data using a .s2p file format for later analysis using the directions presented in class.

File name for short-circuit reflection measurement data: ______________________________

B. <u>SMA Female Short on the end of an F-M Adapter</u>: Connect a F-M adapter between the short used in part A and the test port 1. Set the format to Smith Chart and view the reflection coefficient measurement.

How is the Smith Chart plot appear different than in part A? Why are these differences occurring?

Change the format as needed to find the magnitude and phase at the following frequencies:

100 MHz Magnitude dB	100 MHz Phase Degrees	1000 MHz Magnitude dB	1000 MHz Phase Degrees	3000 MHz Magnitude dB	3000 MHz Phase Degrees

How many zero crossings are in the phase response (do not include -180 to +180 branch cuts in this number)?

Save the data as a .s2p file.

File name for female short on the end of an SMA adapter: ______________________________

C. <u>SMA Female Short on the end of a short (3 to 6 inch) cable</u>: Connect the F short to one end of the short cable provided and connect the other end of the cable to the test port 1. You will need an F-F barrel between the test port and the short cable to allow the connection. Set the format so smith Chart and view the reflection coefficient measurement. Place a marker at 3 GHz and repeat the steps from Part B.

How does the Smith Chart view of the data differ from Parts A and B? Explain:

File Name for Measurement ______________________________________

50 MHz Phase Degrees	0.1 GHz Phase Degrees	1 GHz Phase Degrees	3 GHz Phase Degrees

How many zero crossings are observed in the phase response (excluding the branch cut transitions)? ___

<u>D. SMA Load</u>: Connect the 50 ohm SMA male load provided on the end of the F-F barrel to the port 1 connector. View the result on SWR format and then switch to log-magnitude and Smith Chart formats as appropriate to gather the following information.

Maximum SWR = _________:1 at ____________ MHz

Maximum S11 = __________dB at _______________MHz

Leave the marker set at the above frequency and switch the format to Smith Chart. Record the impedance values that can be read from this view:

Equivalent Load Impedance = _______________Ω + j __________________Ω

How does the Smith Chart representation of the SMA load reflection coefficient differ from the previous measurements?

For a perfect Z_0 load, what SWR would be expected?

For a perfect Z_0 load, what reflection coefficient magnitude (in dB) would be expected?

For a perfect short, what SWR would be expected?

For a perfect short, what reflection coefficient magnitude (in dB) would be expected?

E. Output Cable: Connect the test port to the cable that is attached to port 2 of the VNA. Adjust formats as necessary to make the observations given below:

Maximum SWR = ________________________: 1 at ____________________________ MHz

Maximum S11 = _______________________dB at ____________________________MHz

Leave the marker set at the frequency providing maximum SWR. Switch the format to Smith Chart and read the corresponding impedance values:

Equivalent Load Impedance = __________________________Ω + j _________________________Ω

Does the cable provide more favorable or less favorable conditions for low reflection as compared to the SMA load?

F. Output Cable with 6 dB Pad: Connect a 6 dB attenuator (pad) between the two test cables. Adjust formats as necessary to make the observations given below:

Maximum SWR = ___________________________:1 at ___________________________MHz

Maximum S11 = _______________________dB at __________________________MHz

Leave the marker set at the frequency providing maximum SWR. Switch the format to Smith Chart and read the corresponding impedance values:

Equivalent Load Impedance = ____________________Ω + j ___________________________Ω

What effect does adding the pad have on the measurement? Is it favorable compared to the cable measurement of Part E? What about as compared to the measurement of the SMA load?

Part 2: Transmission Measurements of Cables and Attenuators

A. Leave the 6 dB pad connected to the output cable. Perform a response calibration on Channel 2 of the VNA.

B. Note that, if the VNA is calibrated properly, the thru transmission measurement should have a magnitude of 0 dB and a phase of 0 degrees across the band. Set the FORMAT to log magnitude and press Autoscale. Estimate the residual ripple in the magnitude measurement. <u>A good rule of thumb is that the ripple in the magnitude should be less than +/- 0.1 dB</u>. Now set the FORMAT to phase and record the ripple in the phase plot. A good rule of thumb is that the phase ripple should be less than +/- 1 degrees.

Residual magnitude ripple with thru measurement = +/- _____________dB

Residual phase ripple with thru measurement = +/- _________________degrees

Additional Comments:

C. Transmission measurement of F-M Adapter: Connect the F-M adapter as the DUT and make the following observations in the transmission measurement.

100 MHz Magnitude dB	100 MHz Phase deg.	1000 MHz Mag. dB	1000 MHz Phase Deg.	3000 MHz Mag. dB	3000 MHz Phase Deg.

How many zero crossings are there in the phase response? ________________________

File Name for Measurement = ____________________________________

D. Transmission Measurement of Semi-Rigid Cable

Using markers, obtain the following information.

How many of phase zero crossings are there? ________________________________

What is the magnitude of the transmission coefficient in dB at 3 GHz? _____________________dB

Any Additional Observations:

E. Transmission Measurement of Attenuators/Pads:

Connect the 3 dB pad as the DUT. Use markers to fill in the table of results below:

Pad Value (dB)	100 MHz Magnitude (dB)	1000 MHz Magnitude (dB)	3000 MHz Magnitude (dB)
3			
20			

What is the phase in degrees of the 3 dB attenuator at 1 GHz? _________________degrees

How does the phase response of the 3 dB attenuator compare to the F-M adapter measured earlier?

F. Transmission Measurement of Filter.

Connect the filter between the port 1 cable and the 6 dB pad.

What type of filter is this (lowpass, highpass, bandpass, bandstop, unsure)? __________________

Find the frequency at which the minimum attenuation for the filter occurs:

Minimum Loss: ______________dB at _____________ GHz

Find the 3 dB cutoff frequency or frequencies for the filter (definition: frequency where the transmission coefficient is reduced by 3 dB from the minimum attenuation) fc1 = ____________________GHz fc2 = _____________________ GHz

Display the phase response. How does the general shape of the phase response compare to transmission phase of some of the other components measured earlier in the lab?

File name for measurement: ____