



Lab 1: Scattering Parameter Measurements

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Equipment:

- Agilent 8510C Network Analyzer
- Simple Circuits to measure

Objective:

The objective of this experiment is to become acquainted with the Agilent 8510C Network Analyzer. Demonstrate your ability to calibrate the network analyzer and measure:

- Impedance
- S-parameters
- VSWR

Be able to use the Smith Chart, Log-Mag, and Polar Plot options.

Be able to plot to the plotter and save data to a disk.

Prelab

1. Find equations for the S-parameters for the following simple circuits:
 - a) Short
 - b) Open
 - c) Matched Load (S12 and S21 are meaningless)
 - d) Length of 50-ohm line terminated with short, open, 50-ohm load.
 - e) 3 dB coupler ("S"=input, "1" and "2" are output, and should be -3 dB down from the input)
2. READ the handout on Network Analyzer Calibration

Lab Exercises:

1. *Measure the S-parameters* of the simple circuits listed in 1a-e above from 1-3 GHz. Use the Smith Chart, Log-Mag, and Polar Plot Options. Compare to your expected values.
2. *Measure the impedance and VSWR* of the line terminated with an open as a function of frequency. Use several markers to mark these values.
3. *Plot* at least one of your plots on the plotter in Log-Mag format.
4. *Save* the same data (from part 3) to a disk, and re-plot it in Matlab to obtain the same plot.
5. *Carefully save written instructions/notes* on how to make these measurements (because you will be making them AGAIN). The lab and my instructions for using the Network Analyzer are included, and you are welcome to expand that file with your notes and demos.
6. *Summarize your results.*

What does each S-parameter represent (reflection, transmission, etc.)

How well do your results agree with expected results?



What does a LINE “look” like on a Smith Chart as a function of frequency? Be very clear about WHAT is being shown in this graph (remember each point that is plotted is the impedance seen at the input to the network analyzer cable at the frequency indicated on the marker).

Calibration and S-parameter Measurements with the Network Analyzer

1. **Put on a grounding strap** (everybody ALL the time!)
2. Turn on the power (start with the source *under* the bench, and move up.) You will turn on four “Line/Power” buttons.
3. Attach connectors and extra cables to the network analyzer as needed. Be careful with the network analyzer cables. Do not overbend them.
4. **Calibrate the network analyzer (Regular or TRL).**
 - a. Choose a calibration kit for the type of connector you are using.
 - b. Set your frequency range. On the STIMULUS control, press start and type the frequency you want to start. Do the same for the stop frequency.
 - c. On the MENUS control, press CAL. Delete a calibration set to make room for yours. Do this by pressing MORE on the soft menu on the screen, then DELETE CAL SET, then choose a number.
 - d. Select a calibration type. Generally this is CAL1-7mm unless unless you are using N-type cables.
 - e. Choose the type of calibration you will do. For impedance only, this can be S11 or S22, which is reflection measurement from one port. (Which port depends on which cable you want to use, 1 or 2). Full 2-port is used for through tests, and TRL is used with the microstrip holder.
 - f. You will be prompted to put calibration standards on the end of your cable. They are in the wooden box.
 1. Start with the short (it is labeled) . Connect the short, press the softkey SHORT, and when it is done measuring (quickly) it will underline the SHORT. Take it off, put the plastic cover back on the standard, and find the open.
 2. Open. It is the same length as the short, but with a smaller radius and a hole in the end. Press OPEN, wait until open is underlined, remove the open and replace the plastic cover.
 3. Find the load standard. They are the long, sliding cylinders in the box. Connect it, and press LOAD. Then BROADBAND. Then DONE LOADS. Replace the plastic cover, put all the standards back in the box. (PLEASE! These standards are little and expensive, and if they get lost, we don’t have any others.)
 4. For THRU measurements, use a short coupler (provided with the cal kit) to connect lines.
 5. Omit Isolation measurements.
 - g. Press SAVE 1-port CAL. Press the number where you want to save the cal set. It should say “Correction ON”
 - h. Test your calibration. The worst is usually the open, so put the open standard on again. On the FORMAT menu, press SMITH CHART. You should see a small dot on the right side of the smith chart, but you will probably see a short line. Test the short and load the same way. For the short, you should see a dot on the left side of the smith chart. For the load, the dot should be in the center. IF these are not “clean”, redo the calibration. Factors that can affect your calibration: tightness of cables and connectors, between elements and to the network analyzer.
 - i. If your calibration is good, PUT THE BOX of standards back in the closet.



TO measure impedance. On the FORMAT menu, press Smith Chart. On the MENU menu, press MARKER> Use the thumb dial to move the marker to the frequency you are interested in (printed on the top left side of the screen). You will also two numbers followed by Ω This is the impedance (real and imaginary) in ohms. For more markers, press marker, and choose another number. You can have up to 5 markers at a time (on different frequencies)

TO see the reflection coefficient (S11 or S22) on the FORMAT menu, press LOG MAG. Press MENU (on the FORMAT menu), and this will give you many options for what to print. Originally, it is showing LOG MAG, and the value (at the frequency marked with the marker) is shown in the upper left corner. Other options are LIN MAG, SWR, REAL, IMAG, POLAR, etc.

To change to the scale of a graph, on the RESPONSE menu, press SCALE, and turn the thumb knob until the graph looks like you want it to. Alternatively, choose a scale on the number pad (then press x1 on the number pad).

To get a hard copy on the plotter:

1. Put paper in the plotter (single sheet, set against the light gray stop 2/3 of the way into the plotter.) Hold down with switch on right. Turn on plotter (back left side).
2. On AUXILLARY menu (bottom of Network analyzer panel), Press COPY, Plot to Plotter, specify what to plot (ALL).

To save to disk:

1. Use a DOS formatted floppy.
2. On AUXILLARY menu, press DISC.
3. STORE. More. Data - RAW.
4. This will bring an ABCDEF .. line, prompting for filename. Use the thumb wheel to move to letters, press SELECT LETTER, press Store. This will store in a tabular format. Open it with a simple text editor, load into matlab, etc.