RF and Digital Signal Processing

Network Analyzer Learning Lab

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Introduction

Network Analyzers are great tools for measuring both passive and active parts such as filters, power splitters, amplifiers, couplers etc. In this lab we will simply be getting familiar with the Network Analyzer and what it's key functions are.

Objective

The key objective for this lab is a global one; that is to simply get you familiar with how to use a network analyzer. There will not be a bunch of questions and if you already know how to use network analyzers, you still may want to run through this lab just to get familiar with the particular network analyzer we will be using for the rest of the class. The better you know how to use it the faster you will be able to perform the other labs. If you've never used a network analyzer before, hopefully this lab will give you some insights into their operation and some of the potential pitfalls.

These first two Network Analyzer labs will not be strictly graded as they are mostly there to assist you in learning how to use the equipment, but it is expected that you will run through the exercises.

Directions and Questions

Think of a network analyzer as a signal source and a signal receiver. It's a bit more complicated than that, but, in the final analysis, that is what it is. You sweep the signal source while simultaneously sweeping the narrow band receiver. As your device under test (DUT) responds to the input signal, the detector records the phase and amplitude of the output. I suppose you could think of it as a sort of swept vector voltmeter.

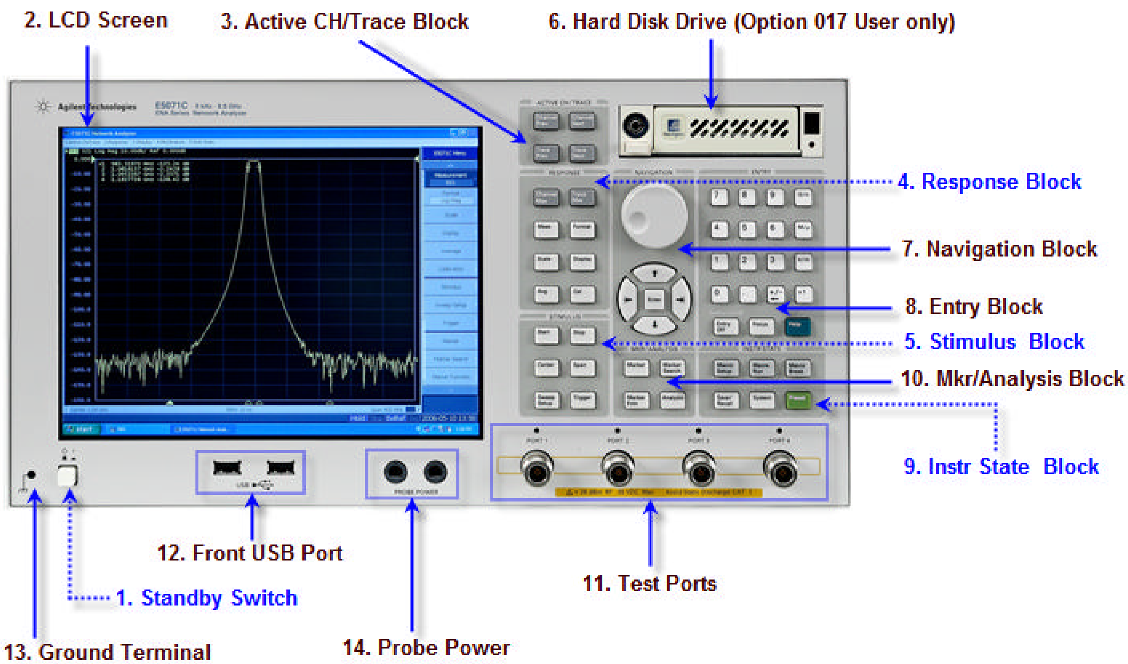
Modern network analyzers allow you to measure all 4 s-parameters of a DUT vs. frequency.

Before making a measurement, it makes sense to think about what you are measuring. That is, if you are measuring a filter, are you just interested in the pass band? Do you want to measure it's rejection at a particular frequency? Do you need to worry about how much input power to apply? What about way out of band? All of these (and more) should be considered before setting up your measurement. If not, you may be forced to revisit the dreaded 2-port calibration (another of today's labs).

In this lab, we will be exploring some of the functionality of the network analyzer and mostly pressing buttons and trying things to see what we can do. Since we'll be using a passive device, you don't really need to worry about potentially blowing anything up.

So…let's get started.

Shown below is the front panel of a model very similar to the network analyzer we will be using.



As you can see, there are a lot of buttons, a dial, a screen, some connector ports etc. If you've never worked one of these before it can be a bit overwhelming. So, let's break it into parts:

1) Stimulus Block. This is where you will set your start and stop frequencies, type of sweep (log vs. linear), power level, etc. Basically this is where you set up your source.

2) Response Block. This is where you set up what you want to measure the response of. Are you interested in S11 (input impedance), S21 (forward gain or loss), S22 (output impedance), S12 (reverse gain or loss). This is also where you will set up the display (split screen etc), do averaging, run calibrations, set the format for what your are measuring (polar, log mag, phase, smith chart etc)

3) Instrument State Block. This is where the preset key lives. If you ever find yourself completely lost, this is the place to go to re-set things to a known operational state. You can also save and recall states and traces here.

4) Marker Analysis Block. This is where you will read values off traces. There are delta markers, marker functions etc which allow you to make fairly sophisticated measurements with the touch of a button.

We will start off ignoring calibration for now (since that's another lab). So, let's get started doing something.

1) Start off by pressing the trusty preset key. This will get you into a known state.

2) Connect the two ports together using a barrel (female-female SMA connector)

3) Set the start frequency to 10 MHz and the stop frequency to the highest rated frequency for the analyzer.

4) Press the channel next/channel prev keys to get to the channel you want to measure.

5) Press the CAL key.

6) Click on calibrate > Response (thru) > select ports

7) Select the test ports (may not be necessary if we only have two ports). We want S21.

8) Click THRU to start the calibration measurement.

9) Click DONE when it's finished.

You should see your trace go from something with roll off to a very flat line at 0 dB.

Change the vertical scale on the analyzer to see how much ripple you have in your response. Make a note of the +/- deviation

_________dB p-p

Now, let's look at the phase.

10) Go to the response block and press on the Format key. Change the format to phase. Look at the vertical axis now and see what the maximum and minimum scale is. Again, zoom in on what should be a flat line and measure the variation in phase after this crude calibration.

__________degrees p-p

11) Set the response back to Log Magnitude and insert the provided SHP-400 in between the two ports (remove the barrel). Scale your amplitude back up to 10/dB per division if it isn't already. If the lowest values are falling off the bottom of the screen move the reference position to the top of the screen. Also, set the reference value to 0 dB (since this is a passive device). Play around with these keys a bit to get a feel for what each one does. For example in 10 dB/div with 10 division, you could set the reference value to -50 dB and the reference position to 5 and still have 0 dB at the top of the screen, or, you could set the reference value to 0 dB and the

reference position to 10, and the trace would not move. Try it. Does anything change? If you see a change in noise floor, it may be because the input attenuator is being automatically adjusted.

12) OK, back to the SHP-400. What does this response look like? What type of filter is this most likely to be?

13) What is the 3 dB cutoff frequency?

14) How much rejection do you get 1 octave away? How about 1 decade?

15) Is this the true rejection? Or…are you measuring some other limitation? How would you find out?

16) Try adjusting the IF Bandwidth to see if you can measure a higher dynamic range. IF Bandwidth can be found under:

    a. Press **Channel Next**/**Channel Prev** keys to select a channel on which to specify the IF bandwidth.
    b. Press **Avg** key.
    c. Click **IF Bandwidth**, then Change the IF bandwidth in the data entry area.

    Did this have any effect on the noise floor? If so, approximately how much? What bandwidth's did you try?

17) Now let's try trace averaging instead.

    a. Press **Channel Next**/**Channel Prev** keys to select the channel on which you want to define the sweep averaging.
    b. Press **Avg** key.
    c. Click **Avg Factor**, then change the averaging factor in the data entry area.

d. Click **Averaging** to turn ON the averaging.

Did this have some effect? If so, was it more or less than the IF bandwidth. Why would this be? Does more averaging drop the noise floor?

18) OK, let's try something new. Remove the filter from between the ports and install a long piece of cable. Measure the insertion loss at the maximum frequency. Make a guess as to the length of the cable (your arm span is roughly the same as your height). Now, calculate the approximate loss in dB/ft of this cable and record it. You should be using markers to make these measurements.

______________dB/ft

19) Go back to phase mode. Try moving your long cable around and see how much phase variation you get. Use markers to help you measure this. Record the phase variation below:

_____________maximum phase variation (peak to peak)

20) Now, go back to the data format menu and select Group Delay Format. What is the group delay of your cable?

_____________(Group Delay) ns.

Use this number to calculate the length of your cable (I know I don't need to tell you that formula). Don't forget your relative dielectric constant of approximately 2.2

$$v_p = \frac{c}{\sqrt{\varepsilon_r}}$$ where c is the speed of light in a vacuum

There is, though, another way to do this.

21) Go back to the Phase Format. You should see this sawtooth like waveform (which is simply the continually wrapping phase.

22) Now, find the Electrical delay key under the Scale key. Try dialing the delay to see if you can flatten out the phase. Once it is fairly flat, compare the delay value to the one you measured above. They should be close since neither of them uses the dielectric constant for the calculation.

23)

24) Let's try Saving some stuff

25) Under the Save/Recall Menu are two ways to save date. One with a graph and one with a screen dump. Try both and see if you can get the data into your own personal computer (or one of the lab computers). Hopefully you will have a USB stick. If not, this is not a requirement.

26) Try exploring the following Data Analysis routines:

    a. Bandwidth Search

    b. Mean/ Standard Deviation, and peak to peak of trace.

    c. Comparing traces, trace math

    d. Set up a limit test

    e. Try using the equation editor to plot the true equation for insertion loss (from lecture).