Matthew Spencer – Fall 2023

Lab 5: Antenna Characterization

In this lab you are going to analyze the behavior of a pair of antennas being measured by a vector network analyzer.

After this lab, you will be able to:

1. Calculate antenna gain from S-parameter measurements of antennas.
2. Describe how to measure a radiation pattern.

<u>Practical Questions</u>

1. What does AUT stand for?
2. What is a calibration antenna?
3. What is multipath?
4. What is an anechoic chamber? What is the purpose of the absorbers in an anechoic chamber?
5. How do you mount antennas to measure them such that the mounting doesn't affect the radiation? A picture of a mount is acceptable.
6. What phenomena can affect your measurement of antenna propagation when you are conducting outdoor antenna tests? How do you mount your antennas to minimize these effects?
7. What is the expected radiation pattern of a patch antenna?
8. What is the input impedance of a backside-fed patch antenna? This answer will be a function of feed location.
9. How is a patch antenna polarized? How would you expect a link between two patch antennas to be affected if one was rotated by 90 degrees relative to the other?
10. Find five factors that we don't consider in the Friis equation that can change the amount of power received at an antenna.

<u>Theory Questions</u>

1. If you apply Pin to a two-port S-parameter network at port 1, which is matched, while port 2 is terminated in a load with a reflection coefficient of Γl, how much power is delivered to the load? (Note: this practice question is here to prepare you for thinking about power gain in question 2.)
2. You measure the S parameters of two antennas connected to the ports of a VNA. One is a well-characterized calibration antenna, so you know it's gain, Gcal. You know the distance between the antennas, r, the S-parameters and the frequencies they were measured at Sxx and ω, and the power level you've specified for the VNA, P1. Write a formula for the gain of the non-calibration antenna. You may not assume S11 or S22 are zero in this measurement, though they are small.
3. What dimension of the antenna in Figure 1 would you use to calculate when it enters far field? What formula would you use to find when it enters far field?

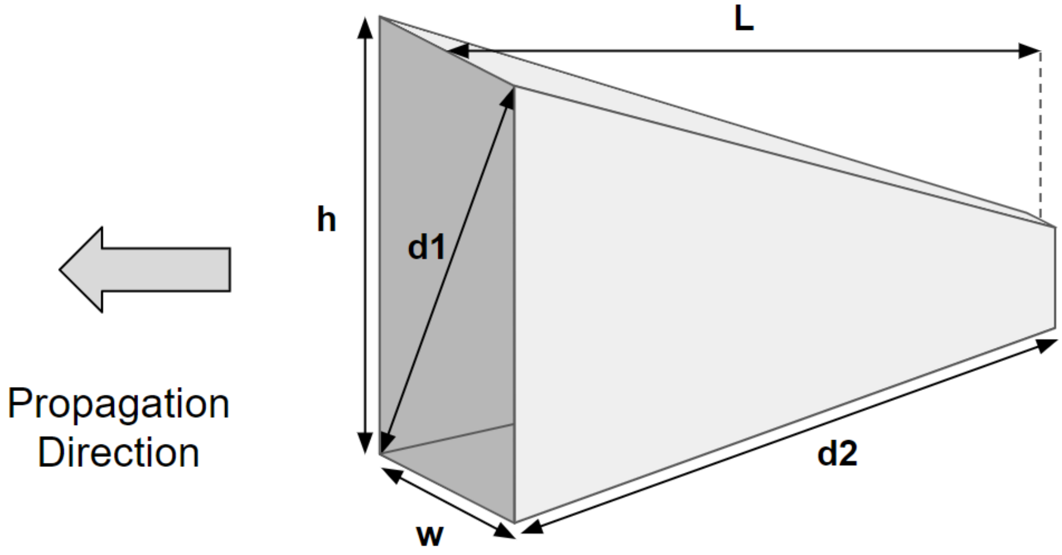

Figure 1

4. Find and read the datasheet for the BBHA9120LF Double Ridged Horn antenna, which is the calibration antenna in our chamber. What are the gain and VSWR of the antenna at 2.4GHz? Use these results to find is |S11| of the antenna at that frequency. http://www.schwarzbeck.de/en/antennas/broadband-horn-antennas/double-ridged-hornantenna/408-bbha-9120-lf-double-ridged-broadband-horn-antenna.html
5. Read the specifications page for the PWTC 48-8 anechoic chamber. What are the maximum and minimum frequencies supported by the absorbers used in the chamber? Determine the frequency at which the test turntable leaves the far field of the calibration antenna. You will need to combine the size of the calibration antenna with the usable internal dimensions of the anechoic chamber to find this frequency. (Note: I think our chamber has a little extra room because of the deal we cut buying it, so make sure to re-measure when you get in lab.) http://www.ramayes.com/Portable_Wireless_Test_Chambers.

Lab Instructions

This lab doesn't require any circuit simulations. Instead of comparing measurement, simulation and analysis for each problem, just compare measurement and analysis. We will use the PWTC 48-8 anechoic chamber, the HP8753D VNA on top of the Anechoic chamber, the Shwarzbeck BBHA9120LF calibration antenna, and the TL-ANT2409A antenna. Datasheets below:

- http://www.ramayes.com/Portable_Wireless_Test_Chambers
- https://www.keysight.com/us/en/product/8753D/network-analyzer-30-khz-to-3-ghz.html
- http://www.schwarzbeck.de/en/antennas/broadband-horn-antennas/double-ridged-hornantenna/408-bbha-9120-lf-double-ridged-broadband-horn-antenna.html
- https://www.tp-link.com/us/support/download/tl-ant2409a/

1. Measure a 2.4 GHz Antenna
    a. Set up a TL-ANT2409A antenna as the AUT in the anechoic chamber.
        i. Find and mount the TL-ANT2409A
        ii. Do a full 2-port calibration of the VNA and fixturing. Note that this calibration requires a bit of creativity because the cables are quite far apart. In the past, students have used long cables and threaded them through the chamber doors during calibration, then often left slack inside the chamber during test.
    b. Measure the S-parameters of the AUT/Calibration antenna 2 port network and analyze them using a link budget.
        i. Back out a plot of input impedance vs. frequency for the AUT
        ii. Use a link budget to back out the gain of the AUT assuming the calibration antenna exactly matches the datasheet. (This is a pretty good assumption based on our tests.)
    c. Use the turntable to measure the radiation pattern of the AUT`. Compare to the datasheet and explain any deviations.
    d. Guess what type of antenna the AUT is based on its gain and radiation pattern.
2. Characterize a patch antenna
    a. A machined patch antenna is sitting on top of the VNA. Use theory to predict its gain, input impedance, operating frequency and radiation pattern. Confirm with the anechoic chamber.
3. OPTIONAL EXTRA CREDIT: Characterize a weird antenna
    a. Pick any weird antenna you can find in the lab and find measure it’s gain, input impedance and radiation pattern. Include a picture of the antenna in your report. Eyeball the antenna dimensions to be sure that its near field is suitable for the chamber (and that it will fit inside!).