Lab 4: 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.
3. Describe how to take near field electromagnetic pre-compliance measurements.

Practical Questions

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. 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?
8. Find five factors that we don't consider in the Friis equation that can change the amount of power received at an antenna.
9. What is pre-compliance electromagnetic testing?
10. What is a Helmholtz coil?

Theory Questions

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?
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?
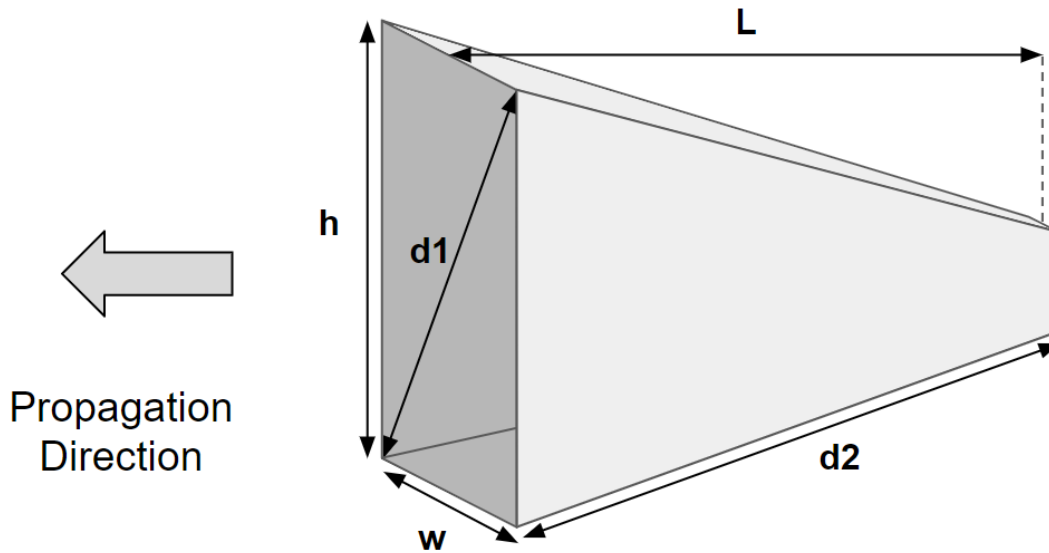
Figure 1

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.
http://www.ramayes.com/Portable_Wireless_Test_Chambers.

6. Describe how you would use a Helmholtz coil to calibrate the Tekbox near-field probes located in the RF lab. Include equations to convert from measured voltages, powers or gains into field quantities. https://www.tekbox.com/product/tekbox-tbps01-emc-near-field-probes/

7. Presume you are measuring the near field of the circuit in Figure 2 with near field probes. What nodes would emit strong E fields? What nodes would emit strong B fields? How could you measure the value of the resistor?
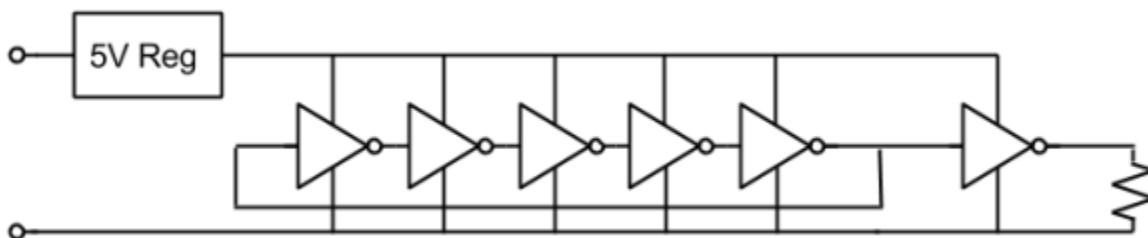

Figure 2

We will not carry out any simulations for this lab.   If you would like to characterize antenna gains in your own home as an optional experimental exercise, I recommend you buy:

- A NanoVNA: https://nanovna.com/ , which comes with calibration standards
- Two patch antennas: https://www.tp-link.com/us/products/details/cat-5067_TL-ANT2409A.html (still available on Amazon)
- Some SMA cable that you can use to de-embed the antennas https://smile.amazon.com/RFAdapter-Coaxial-Antenna-Extender-Adapter/dp/B07YJJ2MCW/ref=sr_1_8

Try to create a link budget that matches your measurements. Calculate far-field boundaries of the measurement before you purchase.