RF Lab Module #5 — Half-Wave Dipole Antenna

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***Abstract*—This lab focuses on the design and analysis of a half wave dipole antenna and how using it affects the magnitude of the radio frequency signal received from a cell phone. Two antennas were manufactured to have their resonant frequency at our test cell phone's de facto frequency. Different configurations were measured and analyzed including using no antenna and cellphone, cell phone to antenna, and antenna to antenna. Each configuration elucidated the clear need for antenna's in todays wireless world.**

I. Introduction

THE modern cellphone is capable of communication at a variety of frequency bands. This lab considers simply the one most easily measurable in practice, in our case 1.8 GHz. With the frequency in mind, our half wave dipole antenna was custom made to best receive the cell phone's signal. The half wave dipole antenna is a straightforward antenna design that, for our purposes only requires a SMA connector and wire. By having 2 antennas manufactured, our procedure allowed for a transmit antenna to be compared with the cell phone's antenna with both having their power received from the same receive antenna. The procedure explores how antennas' distance, orientation, and size play into their effectiveness.

II. Procedure

1) Determine cell phone's operating frequency without an antenna
   a) Connect a coax line to the spectrum analyzer
   b) Move the cable in proximity to the test cell phone
   c) Make a call and note the frequency with the largest power response
2) Construct a half wave dipole antenna with the resonant frequency of the operating frequency
   a) Using the operating frequency, determine the quarter wave length
   b) Cut 2 wire strip a quarter wave length
   c) Solder each wire strip to a SMA connector
   d) Measure the S11 and note the dip as the resonant frequency
3) Measure the received power from the cell phone using the antenna
   a) Connect the antenna to the spectrum analyzer
   b) Make a call and note the signal strength at the operating frequency
4) Construct an identical antenna as in step 2 (Repeat step 2)
5) Measure the received power of the antenna
   a) Connect an antenna to the signal generator as the transmitting antenna. Output 0dB at the cell phone operating frequency
   b) Connect an antenna to the spectrum analyzer as the receiving antenna
   c) With both antenna's in the same orientation measure the received power if they are 30,20,10 cm away.
   d) With their orientations 90 degrees out of phase Measure the received power at 20 cm away.
6) Measure the received power of the cell phone
   a) Connect an antenna to the spectrum analyzer as the receiving antenna
   b) Make a call and measure the received power if the cell phone and antenna are 30,20,10 cm apart.

III. Analysis

Our test cell phone was measured to have an operating frequency of 1.8GHz with an absolute power of -20dBm without an antenna. The power measured when calling with the cellphone was -10dBm with the antenna. Thus, the absolute power was 10 dB larger with the antenna.

Record your measurements and create a table of data. The tables of data are located at Table I and Table II.

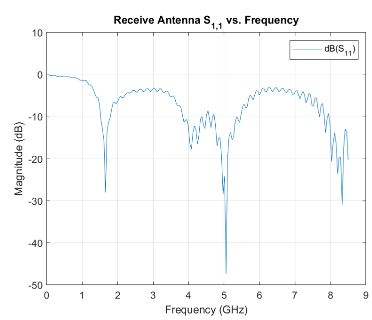

Fig. 1. $S_{1,1}$ vs. Frequency of Receive Antenna

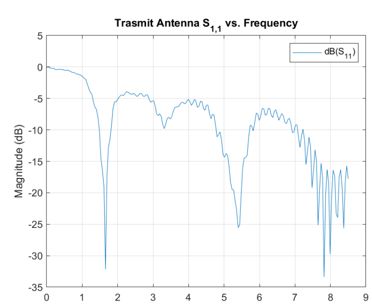

Fig. 2. $S_{1,1}$ vs. Frequency of Transmit Antenna

From the measurements you made, estimate the transmitted power (in dBm) of your cell phone. With the possibly poor assumption that the cell phone antenna will have a similar transmit/receive ratio as the half-dipole antenna to antenna configuration. It is estimated that the cell phone is transmitting 0dBm or 1 mW of power.

What was your measured cross-polarization isolation? Why is it important to keep antennas aligned with the proper polarization?

When the signal generator was transmitting 0dBm through the transmit antenna the receive antenna at the 90 degree orientation received -40dBm. The cross-polarization isolation at 20cm is -40dB. It is important to keep antennas aligned with the proper polarization because misalignment can mean extremely significant losses and a very poor signal to noise ratio.

Include photos of your antennas and measurement setups (cell phone transmit power measurement, etc.)

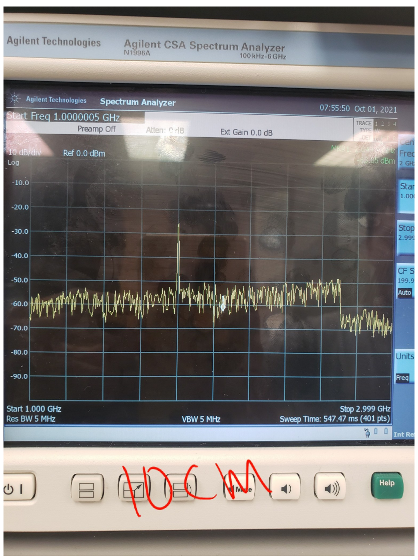

Fig. 3. Antenna to Antenna Power Measurement from 10cm apart

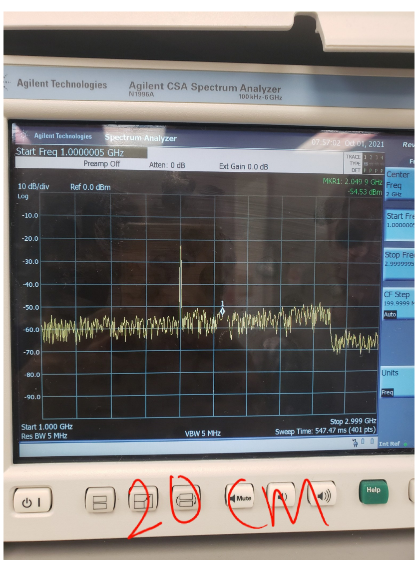

Fig. 4. Antenna to Antenna Power Measurement from 20cm apart

Antenna	Resonant Frequency (GHz)
Transmit	1.6
Receive	1.8

TABLE I
RESONANT FREQUENCIES OF CONSTRUCTED ANTENNAS

Distance (cm)	Measured Power (dBm)
Antenna to Antenna (Same Orientation)	
30	-35
20	-23
10	-18
Antenna to Antenna (Perpendicular Orientation)	
20	-40
Cell Phone to Antenna	
30	-42
20	-38
10	-15

TABLE II
MEASURED POWERS ACROSS CONFIGURATIONS

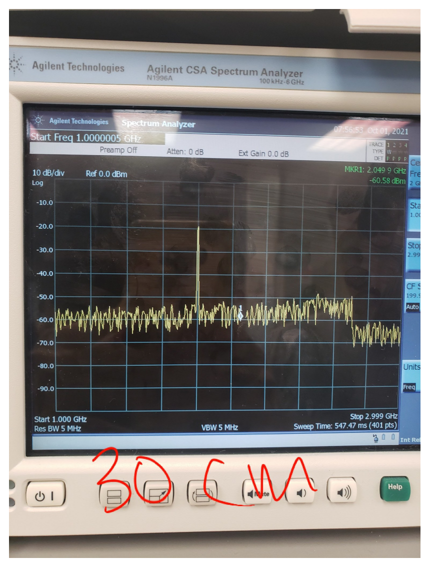

Fig. 5. Antenna to Antenna Power Measurement from 30cm apart

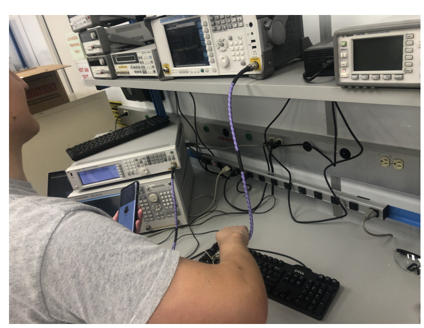

Fig. 6. Phone to Antenna Power Measurement Setup

IV. Discussion and Summary

Overall, in this lab familiarity with antennas and cell phone operation was gained. The importance of antennas in modern society was realized. Significant design decisions such as length of the antenna wires and orientation of communicating antennas showed the nuance behind wireless communication.

Appendix A
Pre-Lab

Design a half-wave dipole antenna using wire and an RF SMA connector. The wire and the RF connector will be provided in the lab.

In the prelab, it was estimated the the operating frequency was 850 MHz.

$$c = \lambda f$$
$$\lambda = \frac{c}{f}$$
$$\lambda = \frac{3 \times 10^8}{850 \times 10^6}$$
$$\lambda = 0.352941\text{m}$$
$$\lambda = 35.2941\text{cm}$$
$$\frac{\lambda}{2} = 17.6471\text{cm}$$
$$\frac{\lambda}{4} = 8.82353\text{cm}$$

Fig. 7. Antenna to Antenna Power Measurement Setup