Experiment Five
Fundamentals of Electromagnetics Lab
EECE2530/1

Michael Brodskiy
Brodskiy.M@Northeastern.edu

November 8, 2023

Date Performed:	November 1, 2023
Partners:	Manas Mahajan & Priyam Modi
Instructor:	Professor Marengo-Fuentes
TAs:	Nicolas Casilli & Farah Ben Ayed

Abstract

The goal of this laboratory experiment was to test radio transmitters (by implementing a Yagi Uda) and radio receivers, and using the LVDAM-ANT software to record and plot the $\vec{E}$-field and $\vec{B}$-field strength. Various dipole lengths were used to determine the best angle for maximum power transmission.

KEYWORDS: transmitter, Yagi Uda, receiver, LVDAM-ANT, dipole, angle, power transmission

1 Equipment

Available equipment included:

- Yagi Uda Antenna (for transmission)
- Dipole Antenna with Modular Length (for receipt)
  - Half-Wave Dipole
  - Full-Wave Dipole
  - 3/2-Wave Dipole
- LVDAM-ANT Radio Transmission Software

2 Introduction & Objectives

We began the experiment by constructing the antennas and choosing the correct lengths for the length of the dipole. As determined in the pre-lab, we began with a half-wave dipole. The antennas were then placed 1[m] from each other, at approximately the same height. A radio-frequency generator was then connected and placed in the 1[kHz] mode. After connecting all the power supplies and launching the LVDAM-ANT software, the application was able to connect to the receiving antenna.

To ensure results that did not oversaturate the antennas, an applicable dB shift was set, and then two measurements was taken. The first measurement recorded the electric field produced by the Yagi Uda (in horizontal orientation), and the second recorded the magnetic field in a similar manner (now vertical orientation). The data acquisition was then repeated for a full-wave and 3/2-wave dipole.

3 Results & Analysis

The results for the half-wave dipole are shown in Figures 1-4:

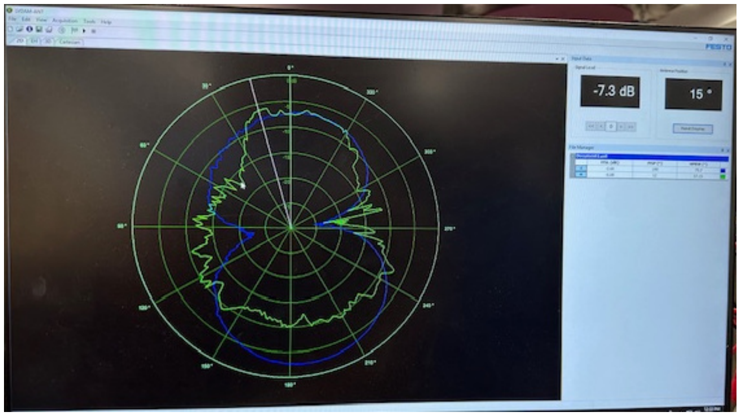

Figure 1: Half-Wave Dipole Polar Plot

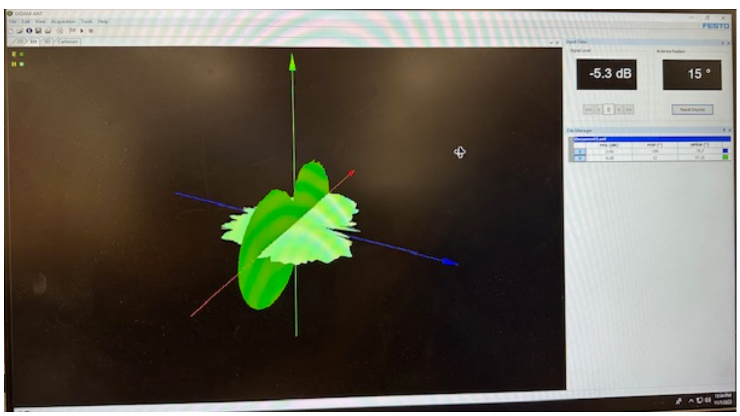

Figure 2: Half-Wave Dipole 2D Plot

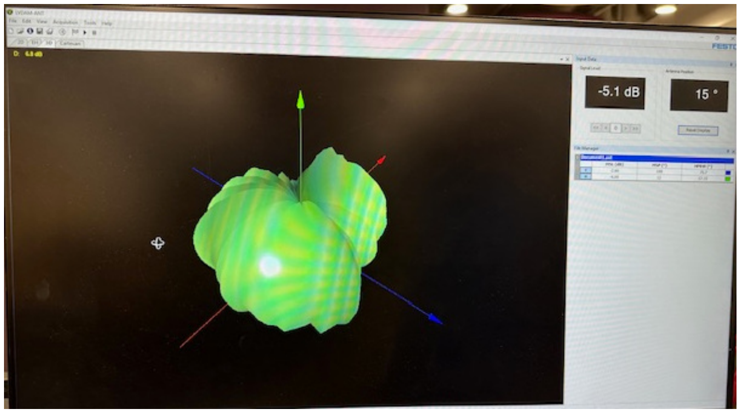

Figure 3: Half-Wave Dipole 3D Plot

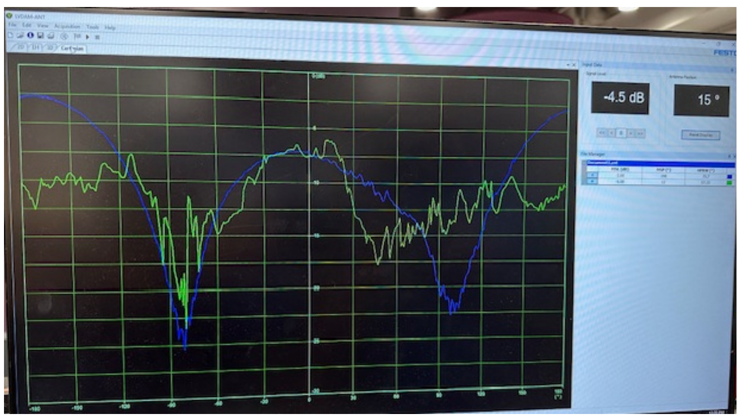

Figure 4: Half-Wave Dipole Cartesian Plot

The results for the full-wave dipole are shown in Figures 5-8:

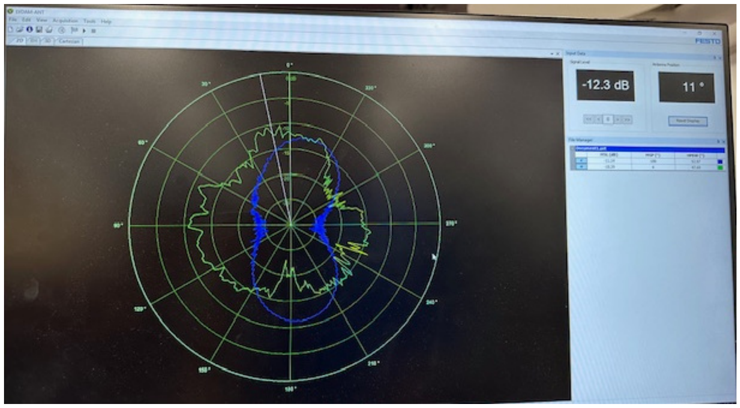

Figure 5: Full-Wave Dipole Polar Plot

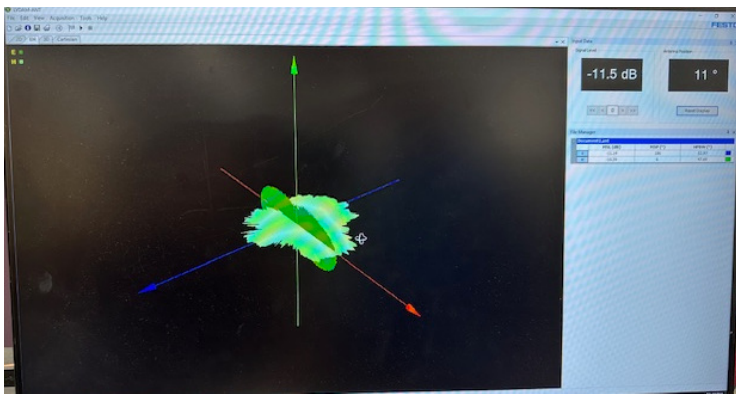

Figure 6: Full-Wave Dipole 2D Plot

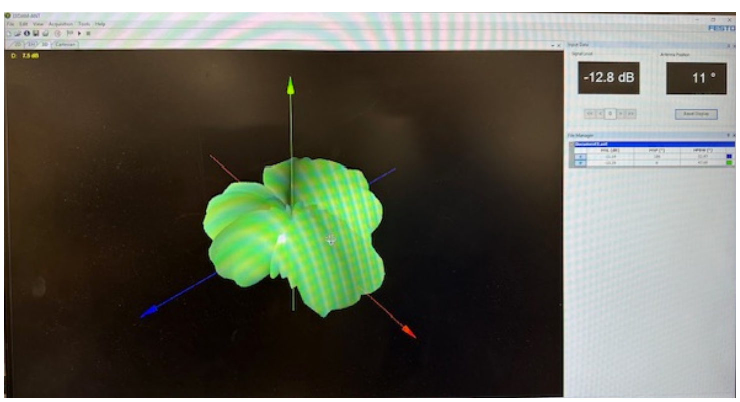

Figure 7: Full-Wave Dipole 3D Plot

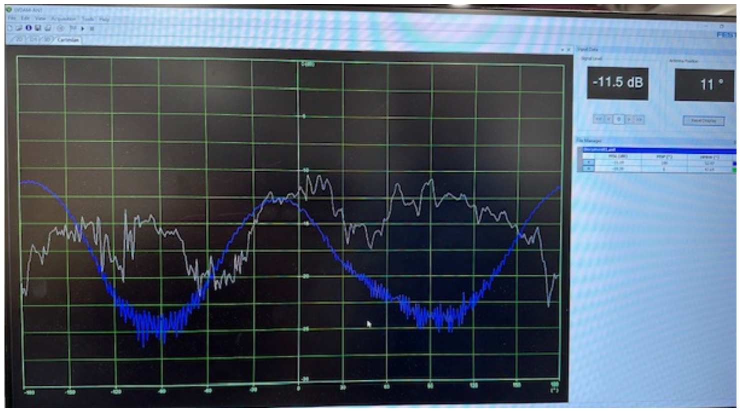

Figure 8: Full-Wave Dipole Cartesian Plot

The results for the 3/2-wave dipole are shown in Figures 9-12:

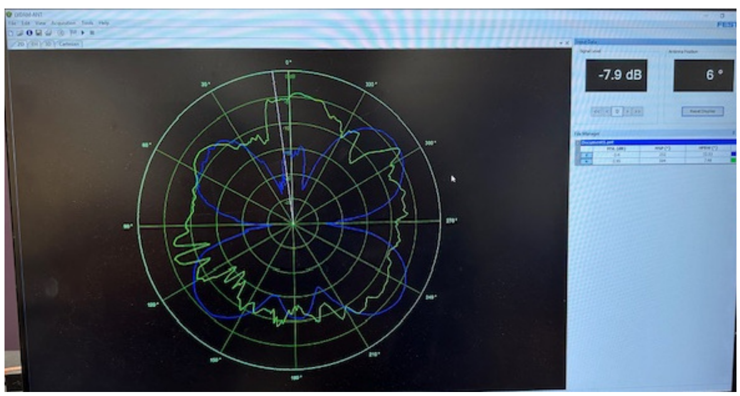

Figure 9: 3/2-Wave Dipole Polar Plot

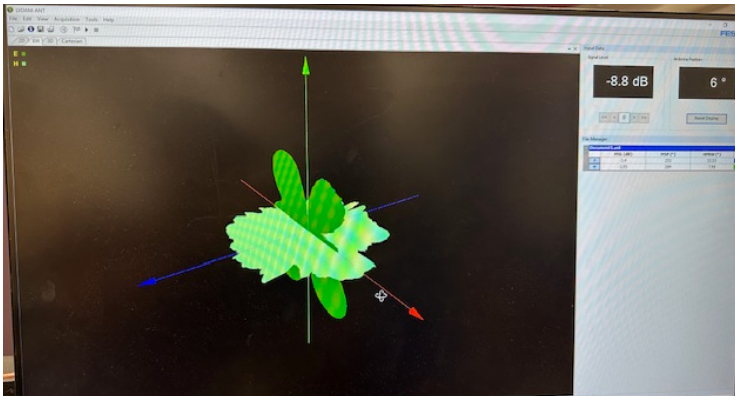

Figure 10: 3/2-Wave Dipole 2D Plot

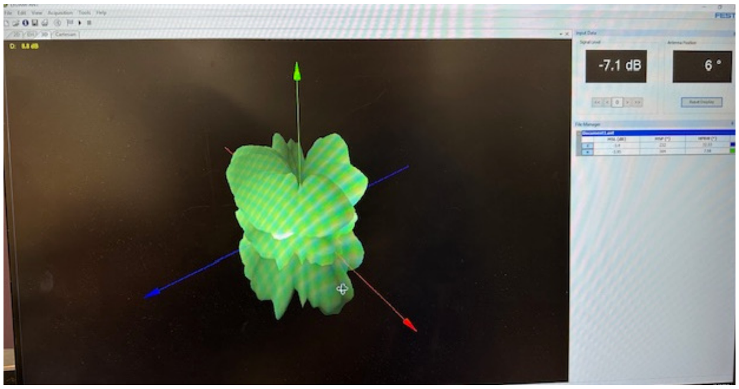

Figure 11: 3/2-Wave Dipole 3D Plot

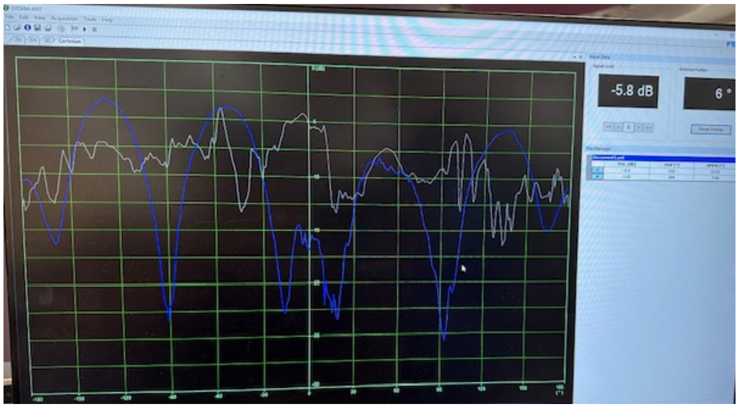

Figure 12: 3/2-Wave Dipole Cartesian Plot

4 Conclusion

4.1 Questions

a. Compare the patterns of the antenna you measured. Did they receive the same power? Please comment referring to the measured data.

   The Festo results seem to be in much more idealized conditions, most likely taken in an anechoic chamber. Comparing this to our graphs, we can see that we received a similar level of power; however, our results experienced much more reflective interference. We know this because the results should be much smoother, whereas, especially with respect to our magnetic field graphs, the results feature many sharp points. In addition to reflective interference, this could have been a result of the clutter of similar experiments being performed close to us.

b. Evaluate the input impedance of the antennas with the presented formulas.

   We know from our formulas that:

$$R_{in} = R_{rad} + R_{loss}$$

   However, for a dipole as effective as this, we can assume R_{loss} is small enough to ignore. Thus, this gives us:

$$R_{in} = R_{rad} = 80\pi^2 \left(\frac{l}{\lambda}\right)^2$$

   This gives us the three input resistances as:

$$R_{in} = \begin{cases} l = .5\lambda, & 20\pi^2 & = 197.39[\Omega] \\ l = \lambda, & 80\pi^2 & = 789.57[\Omega] \\ l = 1.5\lambda, & 180\pi^2 & = 1.776[\text{k}\Omega] \end{cases}$$

c. Evaluate the HPBW for the antennas.

   Though it is difficult to see in the images above, the HPBW can be tabulated as follows:

Dipole Length [m]	Electric HPBW (°)	Magnetic HPBW (°)
$l = .5\lambda$	75.7	57.15
$l = \lambda$	52.97	47.69
$l = 1.5\lambda$	32.52	7.98

   As expected, we can see that, as the dipole gets wider, the HPBW decreases. Essentially, this means that the field is most effectively transmitted within this angle of the dipole. Thus, we know that a larger dipole would receive a more directed field, which is indicated by the data.

d. What if we rotate the Yagi and transmit with the dipole? What do you expect to see?

   In general, a Yagi Uda is better a transmission, while a dipole is better at receipt. Thus, in reversing the roles, we would expect the radiation to be less directed. This would mean the HPBW values would increase, which would indicate less power arriving at the Yagi Uda. As such, we would expect to see a weaker field with a greater HPBW.

e. Why is the Yagi a good antenna to test other antennas?

   Yagi Uda antennas are good because of their high directionality. Because of the structure, the produced field is generally well-directed, allowing for greater power transmission in a certain direction, as evident by the fairly low HPBW values. As such, because they are capable of directing their signals better than other antennas, it is easier to test receivers.

4.2 Summary

Overall, we were able to successfully generate all of the necessary plots and data from testing the antennas. It is visible for nearly all of the plots, however, that significant reflections interfered with some of the transmissions.