I. Introduction

The goal of this lab was to determine the radiation patterns and gain of the pyramidal horn antenna by measuring the signals from the receiving antenna and observing them in the Network Analyzer.

II. Theory

For this lab, we used the concepts of antenna gain, and E-plane and H-plane half-power beamwidth of the radiation patterns. The antenna gain is directly proportional to the height and width of the horn antenna, and inversely proportional to the E-plane and H-plane half-power beamwidth of the radiation patterns. This is portraited by the following relations:

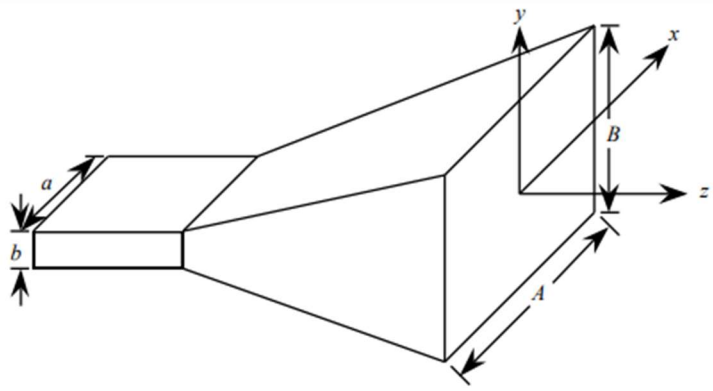

Figure 1: Pyramidal Horn Antenna schematic

$$G = \frac{1}{2}\frac{4\pi}{\lambda^2}(AB)$$

Equation 1: Gain of Pyramidal Horn Antenna with respect to the width and height of the outer area of the horn

$$G = \frac{26000}{HP_E^{\circ} HP_H^{\circ}}$$

Equation 2: Gain of Pyramidal Horn Antenna with respect to E-plane and H-plane half-power beamwidth in degrees

$$HP_E^{\circ} = 54\frac{\lambda}{B}$$

Equation 3: E-plane half-power beamwidth with respect to antenna height

$$HP_H^\circ = 78\frac{\lambda}{A}$$

Equation 4: H-plane half-power beamwidth with respect to antenna length

For all equations, G refers to the gain of the receiving pyramidal horn antenna, HP_E refers to the E-plane half power beamwidth in degrees, HP_H refers to the H-plane half power beamwidth in degrees, B refers to the height of the outer area of the horn antenna, and A refers to the width of the outer area of the horn antenna. By observing Fig. 1, we can get an image of what A and B in better detail.

III. Methodology

For this lab, we first performed a two-port calibration for a power sweep at a CW frequency of 5.5 GHz

We then placed the transmitting and receiving horn antennas 6 meters away from each other and facing each other as well. We connected port 1 of the Network Analyzer (NA) to the back of the transmitting antenna, and port 2 of the NA to the back of the receiving antenna using probes.

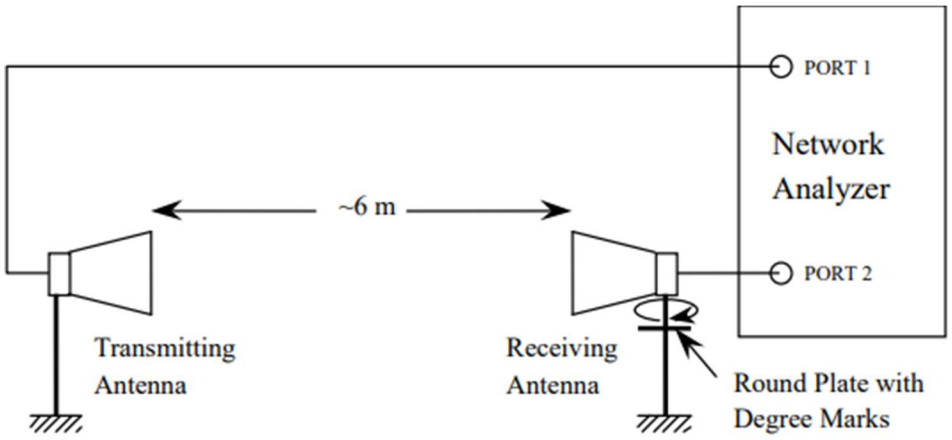

Figure 2: setup for Pyramidal Horn Antenna Lab

Figure 2 helps us visualize the horn antennas' placement and setup, and how they connected to the NA as explained above.

The antennas were adjusted to be at level with their broad walls oriented horizontally. We took dB magnitude measurements of the transmission coefficients, using an averaging factor of 20, starting at zero degrees for the round plate of both receiving and transmitting antenna (see Fig. 2), and making measurements every 30 degrees, all the way up to 90 degrees for both antennas. We repeated this process in the opposite rotating direction and recorded these values with the NA as well.

We further removed the antennas' horns and reassembled them with their width (A) vertically, and height (B) horizontally this time. We repeated the same steps of measurement as before, and recorded such values.

IV. Results & Discussion

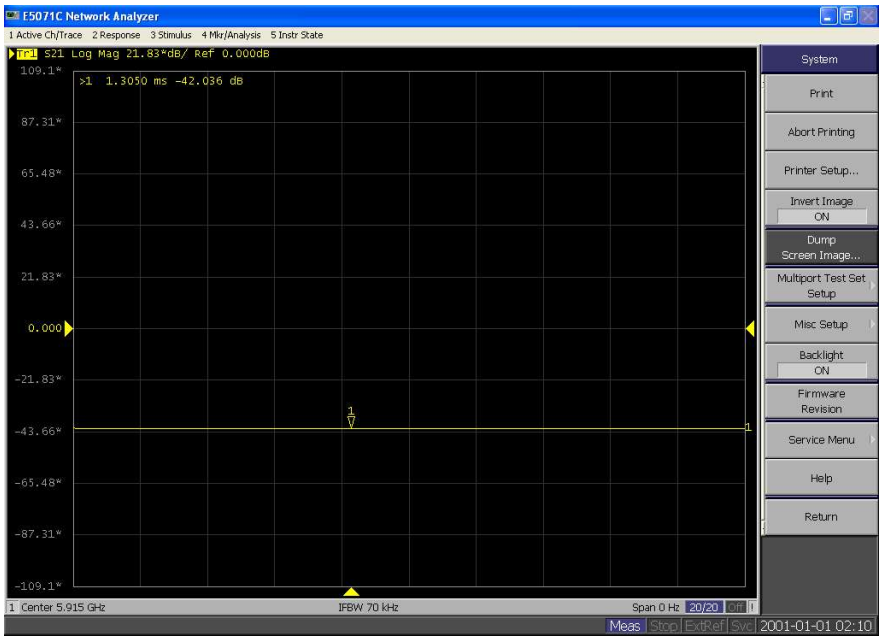

Figure 3: Horizontal measurements for 0 degrees

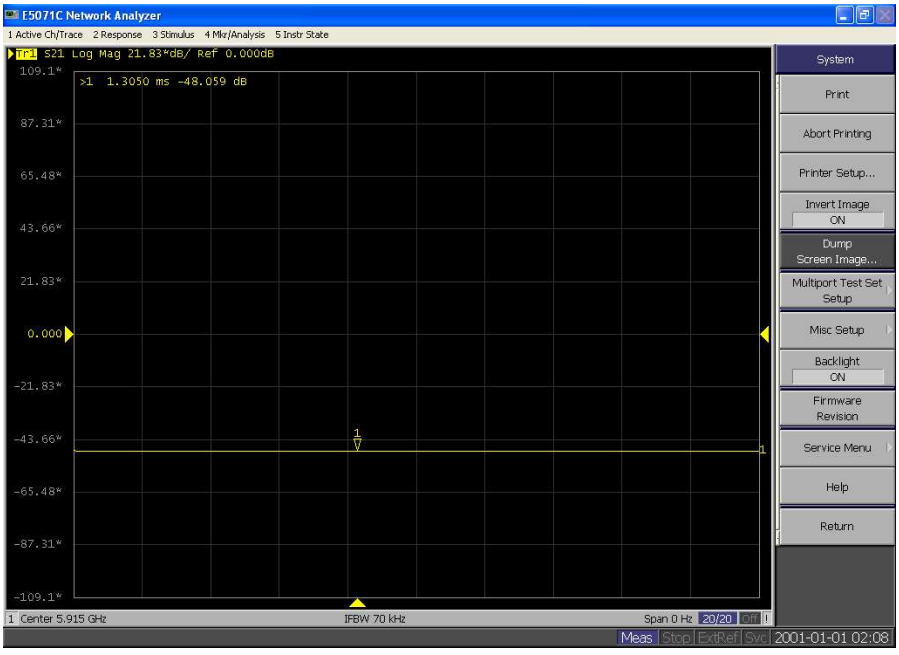

Figure 4: Horizontal measurements for 30 degrees

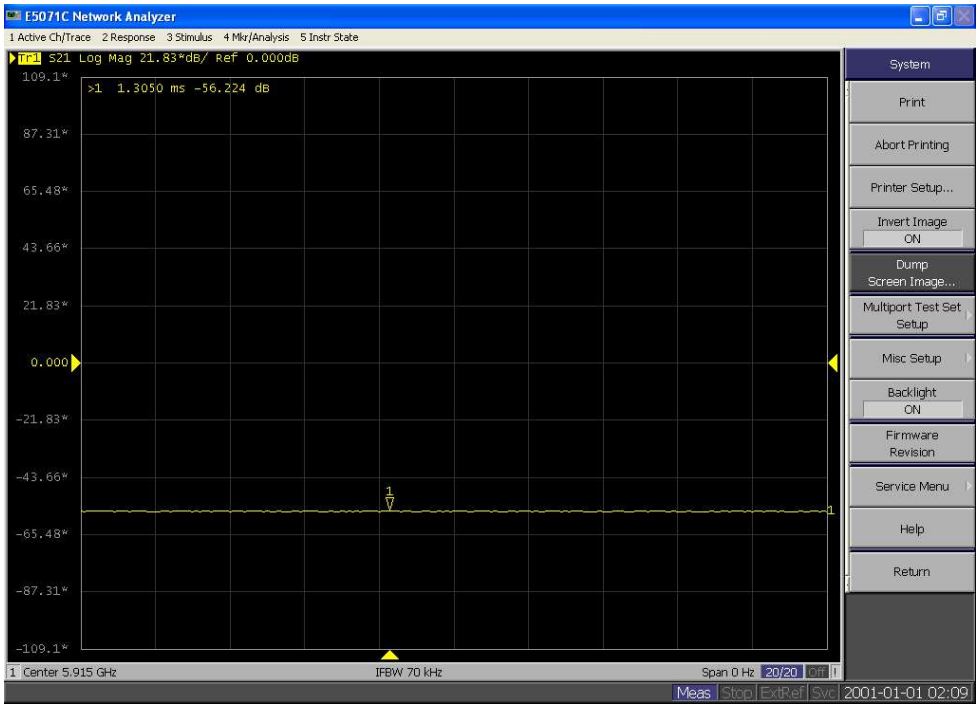

Figure 5: Horizontal measurements for 60 degrees

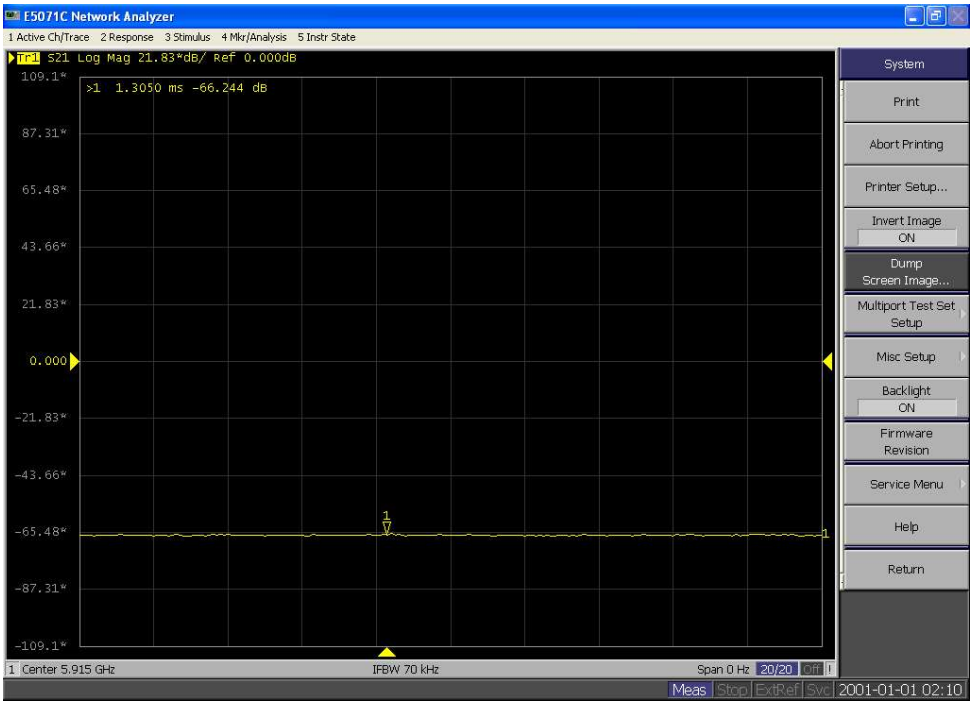

Figure 6: Horizontal measurements for 90 degrees

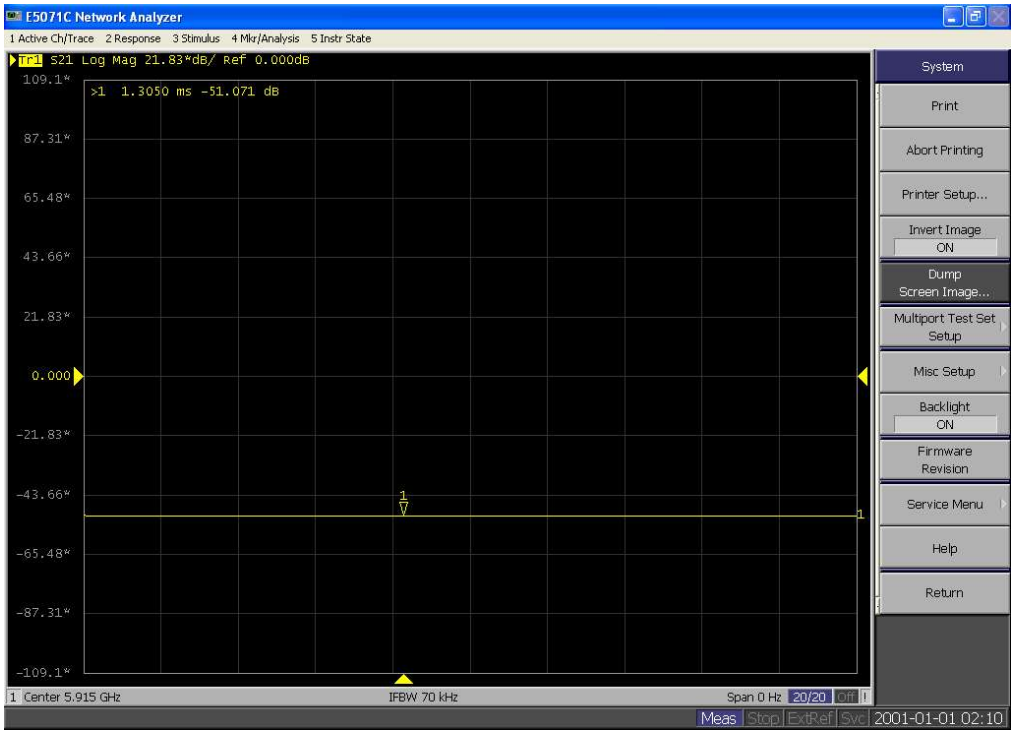

Figure 7: Horizontal measurements for -30 degrees

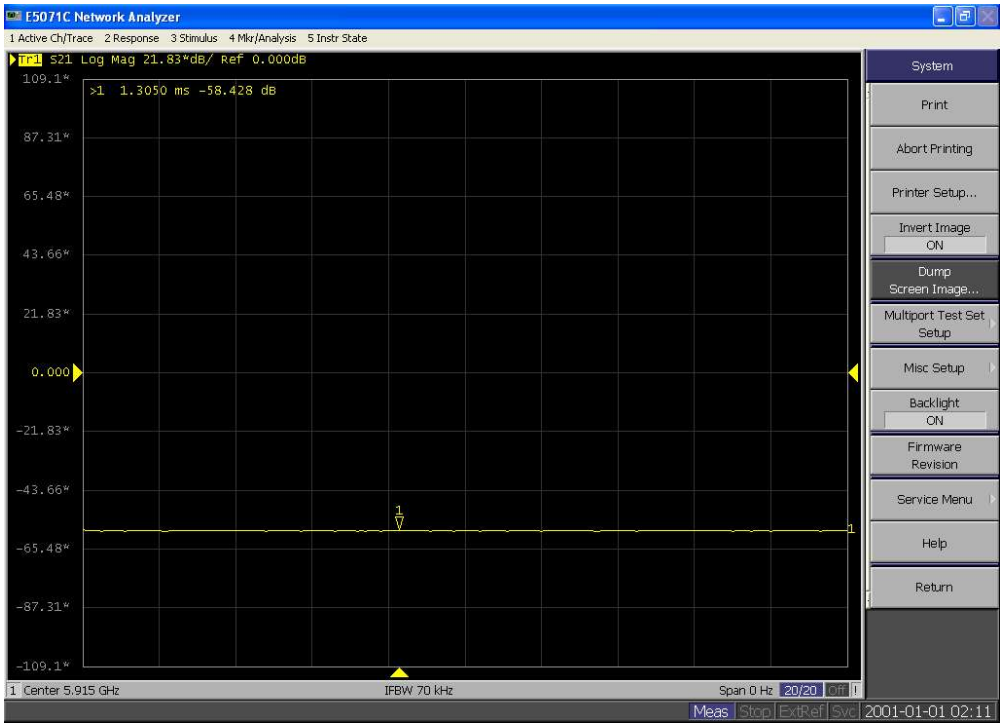

Figure 8: Horizontal measurements for -60 degrees

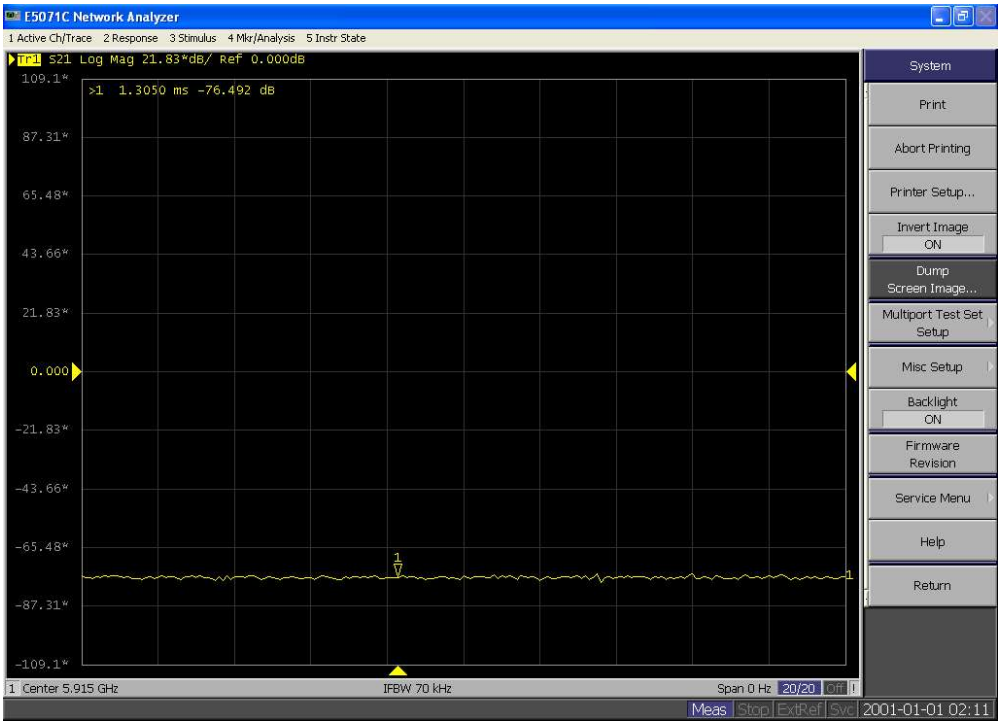

Figure 9: Horizontal measurements for -90 degrees

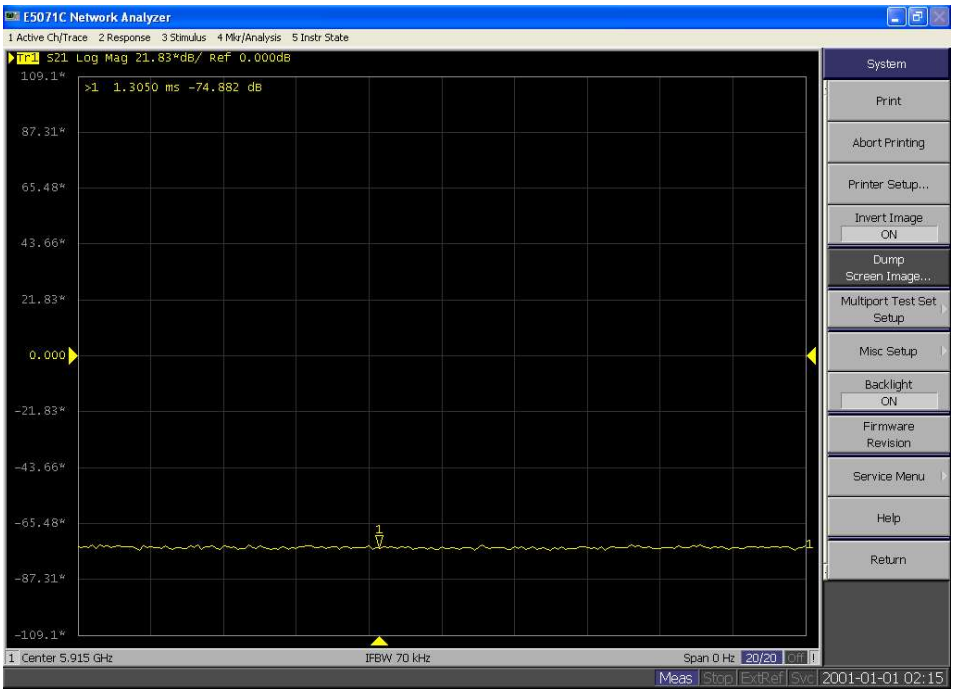

Figure 10: Vertical measurements for 0 degrees

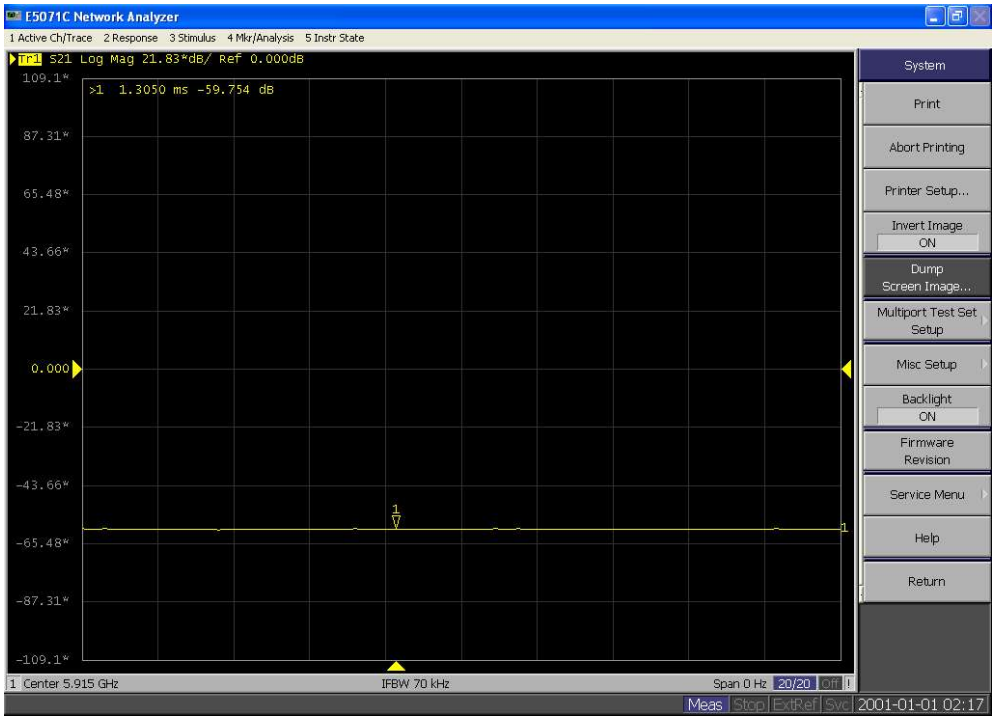

Figure 11: Vertical measurements for 30 degrees

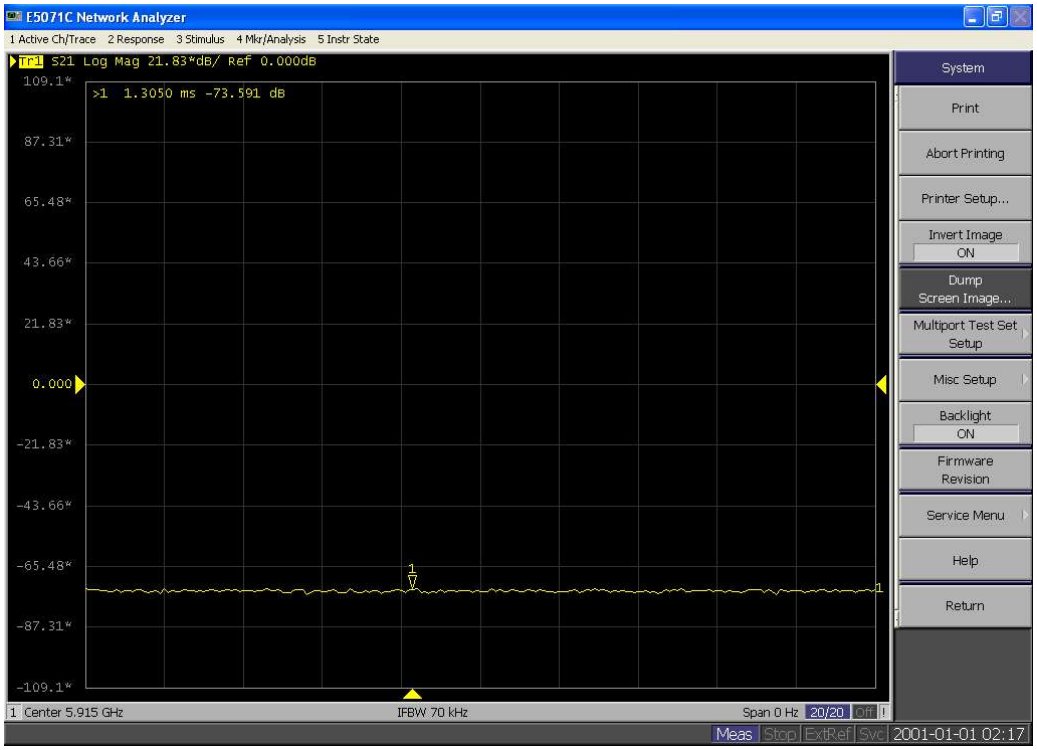

Figure 12: Vertical measurements for 60 degrees

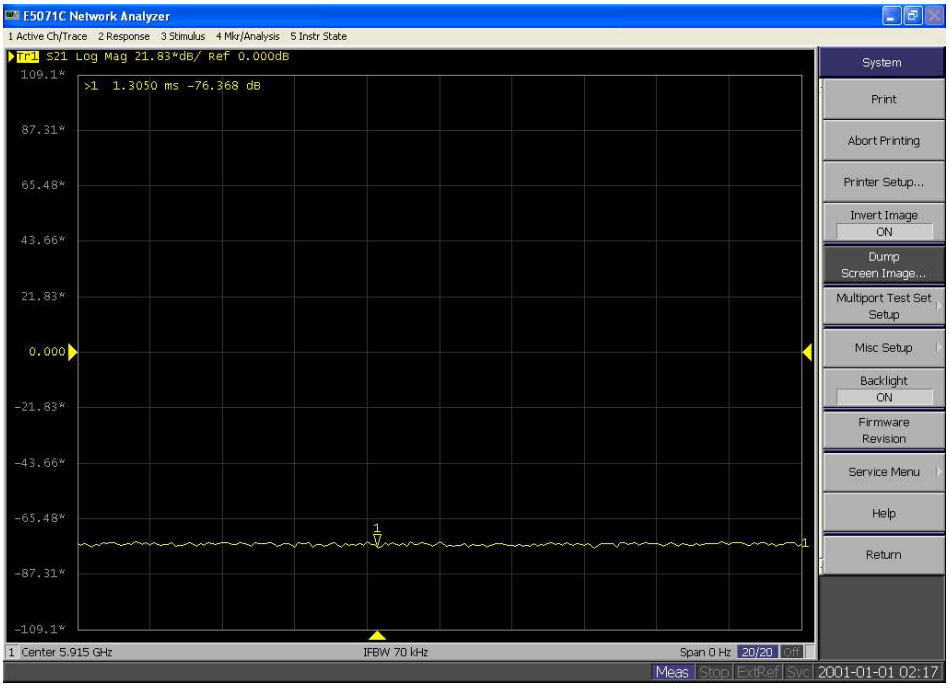

Figure 13: Vertical measurements for 90 degrees

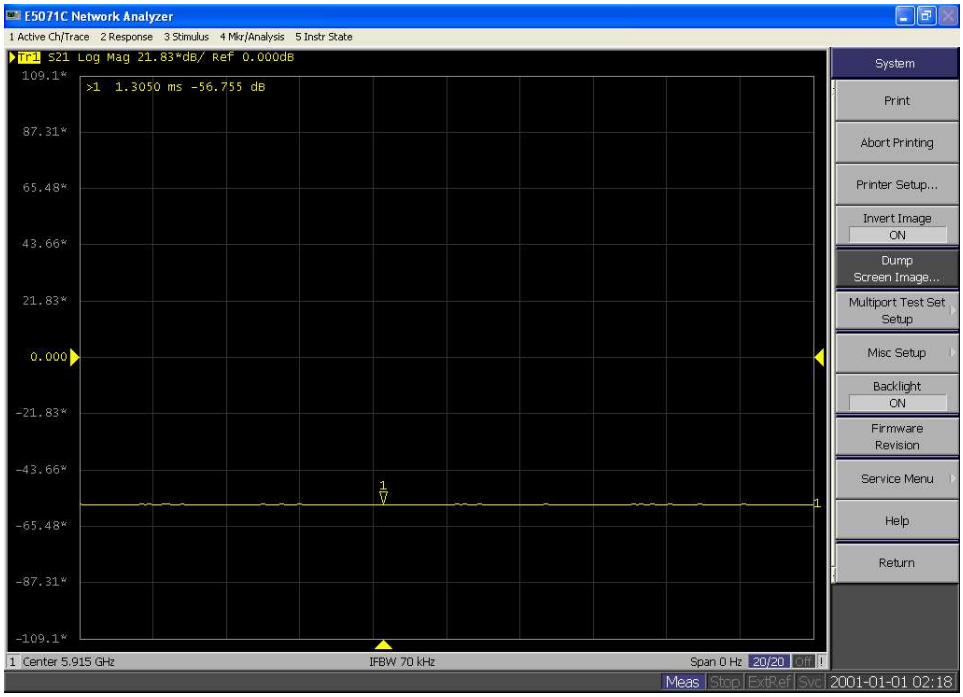

Figure 14: Vertical measurements for -30 degrees

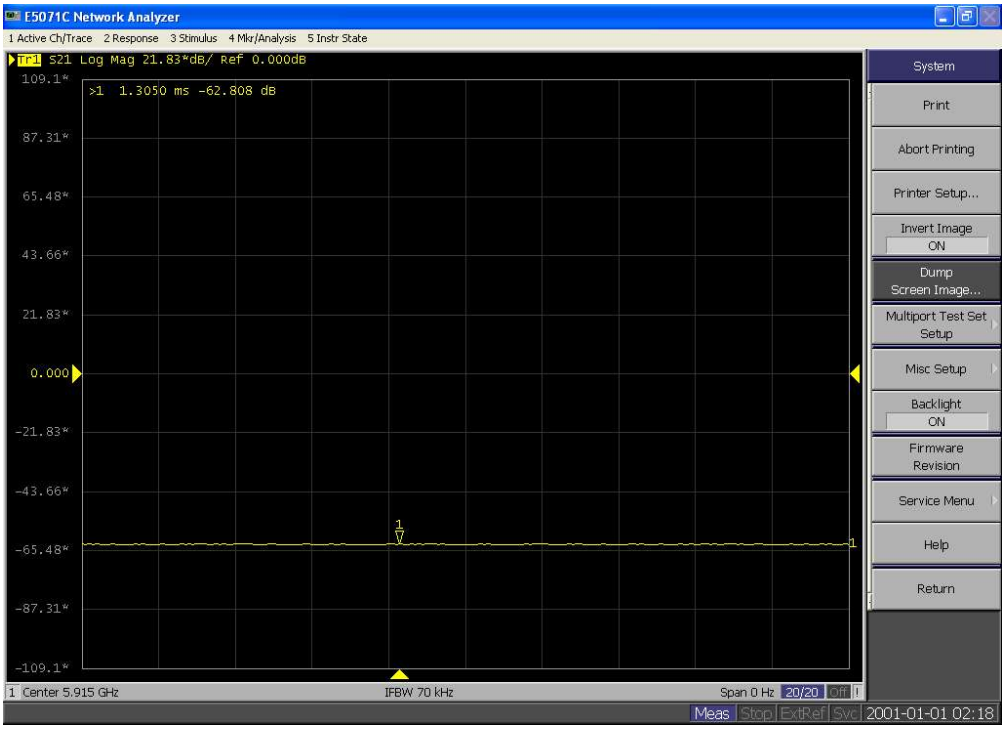

Figure 15: Vertical measurements for -60 degrees

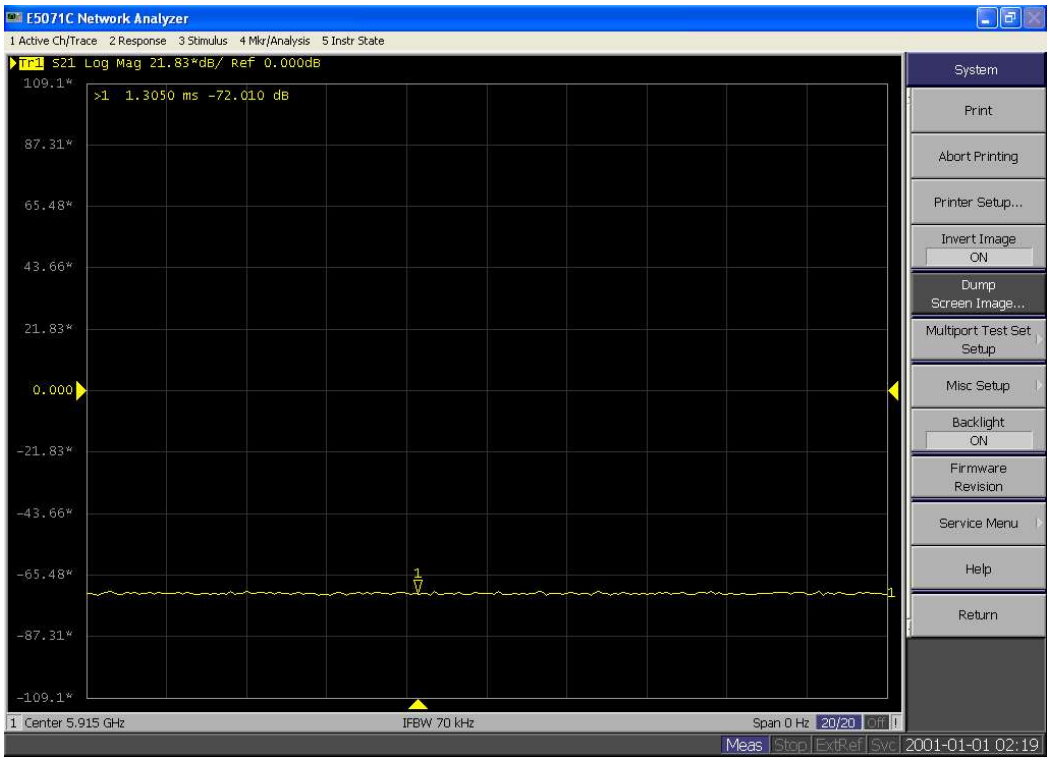

Figure 16: Vertical measurements for -90 degrees

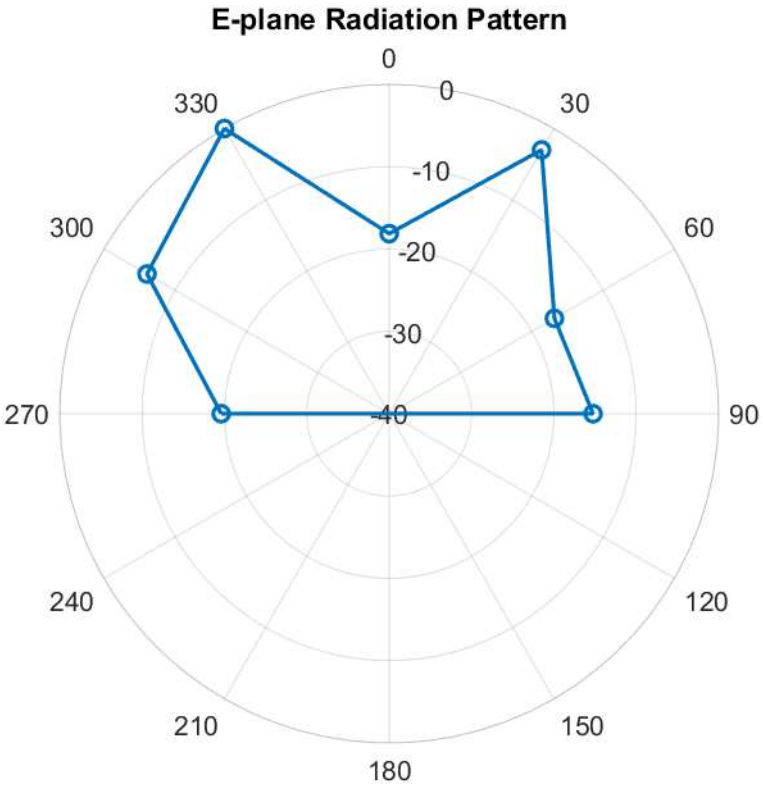

Figure 17: E-Plane Radiation Pattern Measured

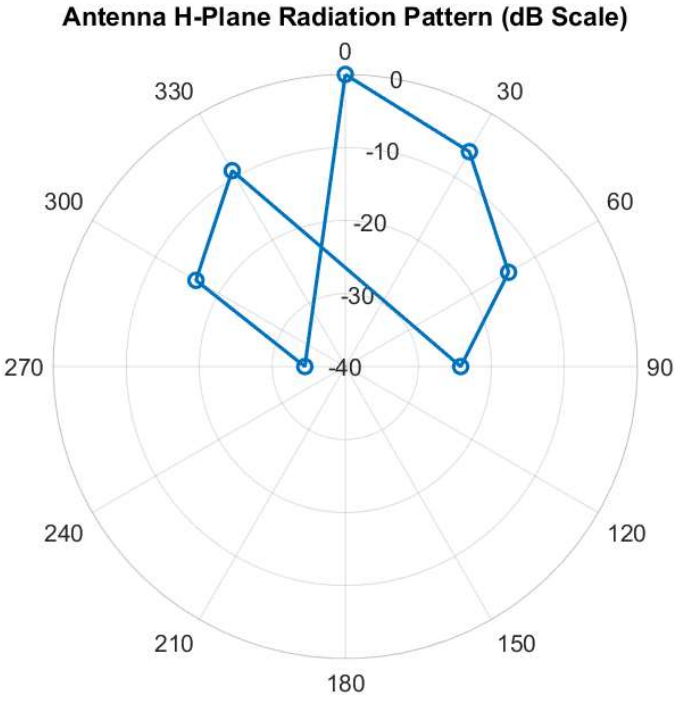

Figure 18: H-Plane Radiation Pattern Measured

From Fig. 17 & 18 we were able to find the half-power beamwidth of the H-plane to be $HP_H^o = 24.86^o$ and $HP_E^o = 74.95^o$.

Applying Eq. 2 to the found half-power beamwidths, we get an antenna gain of 13.954.

Given a wavelength of 0.0545077 m, a B height of 0.1 m, and a width of 0.05 m, and applying such values to Eq. 1, we calculated a gain of 10.574.

V. Conclusion

The goal of the lab was to determine the radiation patterns of the pyramidal horn antenna and get a better understanding of how they work. From Electromagnetics 2 theory, and observing Fig. 17 & 18, we understand that the H-plane and E-plane radiation patterns follow an upside down 8 shapes, resembling an infinity symbol ideally.

We can notice that Fig. 17 appears to be less clear and accurate than Fig. 18, suggesting our measurements for the E-plane required more precision and attention to detail before recording them. Our result for the gain is close to the theoretically expected value, but the E-plane measurements seem to introduce greater uncertainty to the measured gain.

Overall, we were able to understand the common behavior of pyramidal horn antennas receiving gain and learn for future labs to increase the number of measurements to improve the experiment accuracy, plus paying close attention when registering and naming each saved measurement. Double-checking with teammates is a good approach towards further improving lab results.