# EE 483L/583L Antennas for Wireless Communications (Spring 2025)
# Laboratory 3- Antenna Input Measurements

## Introduction

In this laboratory, you will be taking measurements on a horn antenna connected via waveguide and adapters to a coaxial transmission line using a vector network analyzer (VNA), Keysight E5063A. The waveguide has a cut-off frequency $f_c$ of 6.557 GHz. However, its *usable* low-end frequency is significantly higher.

**Experiment** (You may work in groups of two.)

1) The instructor will have the antenna, 6' coaxial cable, adapters, Keysight E5063A vector network analyzer (VNA), Agilent 85033E 3.5mm Calibration Kit, pliers, tape measure, and wrenches available. Remember to include an equipment table with all relevant equipment information in logbook, i.e., description, manufacturer, and model number (as applicable).
2) Take picture(s) showing the horn antenna-waveguide-coaxial adapter system (i.e., the antenna). with relevant dimensions (i.e., include ruler/tape measure in picture) and information. [Hint: aperture dimensions and length of horn.]
3) If necessary, power on the VNA. Connect a Type N (m) - SMA (f) adapter and the 6' coaxial cable to Port 1 of the VNA.

**Wear a static wristband whenever working with the VNA!**

**Torque coaxial connections using torque and box wrenches (mechanical support)!**

3) To begin, select the frequency range and settings for the VNA. The frequency should range from 6.5 GHz to 8.5 GHz in steps of 2.5 MHz. Calculate and record the number of data points required. Use data averaging with an averaging factor of 8. Press the Format button and use the mouse to select <Smith> and then <R +jX> to display an impedance Smith chart.
4) Per earlier lab, calibrate the VNA to the reference plane of the SMA (m) connector on the open end of the coaxial cable. I.e., we do not want the cable to be part of our measurements.
5) Connect an SMA (f) – N (m) adapter (needed to attach the antenna) to the end of the cable.
6) Activate Marker 1 and put it in the middle of frequency range $f_{mid}$. Is the marker at the $\infty\ \Omega$ point where $\Gamma = 1\angle 0°$ on the Smith chart? If not, the VNA will need to be adjusted. Press the Scale button and use mouse to select <Electrical Delay>. Adjust the electrical delay to move Marker 1 roughly to the $\infty$ point on the Smith chart. Then, switch to the phase format (i.e., $\angle S_{11}$) display. Set scale to 5°/div. Refine the electrical delay so that the phase is as close as possible to 0°. Record your specific electrical delay $\Delta t_{delay}$.
7) At these frequencies, the adapter introduces a measurable/noticeable amount of loss. Change the display format to Log Mag, i.e., $20 \log_{10} |S_{11}|$.
   - Adjust the display so that 0 dB is 1 division down from the top and the scale is 0.1 dB/div.
   - Use Marker Search to move Marker 1 to the maximum Log Mag, i.e., minimum loss.
   - Activate Marker 2 and place at $f_{mid}$.
   - Activate Marker 3 and use Marker Search to find minimum Log Mag, i.e., maximum loss.
   - Save a screen shot of the Log Mag display. Leave room for screen shot in logbook.

8) Change the display format to Lin Mag display format, i.e., $|S_{11}|$. Do not move markers.
   - Adjust the display so that $|S_{11}| = 1$ is 1 division down from the top and the scale is 0.1/div.
   - Save a screen shot of the Lin Mag display. Leave room for screen shot in logbook.
9) Connect the antenna. Place in a location where the antenna and cable will not be disturbed with antenna pointed away from any close objects. Draw block diagram(s) of the test set-up.
10) Change the display format to SWR.
   - Adjust the display so that an SWR of 1 is at the bottom and the scale is 0.2/div.
   - Place Marker 1 at the lowest frequency where the SWR = 1.5.
   - Place Marker 2 at $f_{mid}$. Place Marker 3 at the lowest SWR.
   - Save a screen shot of the SWR display. Leave room for screen shot in logbook.
11) Change the display format to Lin Mag, i.e., $|S_{11}|$.
   - Adjust the display so that $|S_{11}| = 0$ is at the bottom and the scale is 0.05/div.
   - Place Marker 1 at the lowest frequency where $|S_{11}| = 0.2$.
   - Leave Marker 2 at $f_{mid}$. Place Marker 3 at the lowest $|S_{11}|$.
   - Save a screen shot of the Lin Mag display. Leave room for screen shot in logbook.
12) Change the display format to Log Mag. Leave markers in place.
   - Adjust the display so that 0 dB is one division down from the top and the scale is 2.5 dB/div.
   - Save a screen shot of the Log Mag display. Leave room for screen shot in logbook.
13) Change the display format to an impedance Smith Chart. Leave markers in place. Save a screen shot. Save trace data. Leave room for screen shot in logbook.
14) If no other groups are waiting, power down the VNA.

**Analysis**

1) Estimate best and worst case one-way losses (% and dB) through SMA (f) – N (m) adapter.
2) Is the antenna usable at the cutoff frequency $f_c$ of the waveguide? Why or why not?
3) How does the lowest frequency where the SWR = 1.5 compare to $f_c$? [Express as $f_{1.5}/f_c \times 100\%$.] What value of $|S_{11}|$ corresponds to SWR = 1.5?
4) How does the lowest frequency where $|S_{11}| = 0.2$ compare to $f_c$? What percentage of the incident power is reflected when $|S_{11}| = 0.2$?
5) At the lowest frequency where $|S_{11}| = 0.2$, what is the Log Mag? How does this compare with the commonly used specification that the Log Mag be $\leq$ -20 dB?
6) Create rectangular plots of resistance versus frequency and reactance versus frequency. Insert plots in the logbook. Comment on how the input impedance with frequency.
7) Assuming a standard gain horn antenna and considering the horn dimensions, search the internet for the expected operational frequency range and nominal gain. To what Radar band designation does this most closely correspond? Document reference sources and include relevant excerpts to support answer. How does the expected low frequency compare to the Marker 1 frequencies?

**Report**

- Following syllabus guidelines, compose a short report on this lab.

**Report and logbook due Wednesday, February 19, 2025 at class.**