EE 481/581 Microwave Engineering (Fall 2024)
Laboratory 5 Waveguide and Horn Antenna

Background

In this laboratory, you will be taking measurements on a horn antenna connected via waveguide to a coaxial connector. Document all work in a logbook.

Preliminary

1) See instructor to access the horn antenna-waveguide-coaxial adapter system (i.e., the antenna). Take picture(s) showing the antenna with relevant dimensions (i.e., include ruler/tape measure in picture) and information.
2) Measure and record the interior waveguide dimensions (mm and inches).
   - Using the EIA nomenclature, what type of waveguide is included with the antenna?
   - What does the acronym 'EIA' signify?
   - What is the lowest mode and corresponding cutoff frequency f_c (GHz) for the waveguide?
   - Document reference sources and include relevant excerpts to support answers.
3) Find datasheet for the coaxial to waveguide adapter.
   - What type of coaxial connector is used?
   - What is the coaxial transmission line characteristic impedance?
   - What type of waveguide is used?
   - What is the matching specification for the adapter?
   - Document reference sources and include relevant excerpts to support answers.
4) Measure and record the interior horn aperture dimensions (mm and inches).
   - Assuming a standard gain horn antenna, what is the 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.

Experiment

1) The instructor will have the antenna, 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) If necessary, power on the VNA. Connect a Type N (m) - SMA (f) adapter and the cable to Port 1 of the VNA.

Wear a static wrist band 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 GHz to 8.5 GHz in steps of 2 MHz. Calculate and record the number of data points required. Use data averaging with an averaging factor of 16. Press the Format button and use the mouse to select <Smith> and then <R +jX> to display an impedance Smith chart.

4) Per earlier labs, calibrate the VNA to the reference plane of the SMA (m) connector on the open end of the cable. I.e., we do not want the cable to be part of our measurements.

5) Connect the SMA (f) – SMA (f) (AKA: a 'bullet') plus N (m) – SMA (m) adapter combination (needed to attach the antenna) to the end of the cable.

6) Activate Marker 1 and put it in the middle of the frequency range. Is the marker at the $\infty\ \Omega$ point (or $\Gamma = 1\angle 0°$)? If not, the VNA will need to be adjusted to get as close as possible to this point. Press the Scale button and use the mouse to select <Electrical Delay>. Adjust the electrical delay to move Marker 1 roughly to the desired 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 Δt_{delay}.

7) At these frequencies, the adapters introduce a measurable/noticeable amount of loss. Change the display format to Log Mag.
   - Adjust the display so that 0 dB is 1 division down from the top and the scale is 0.2 dB/div.
   - Leaving Marker 1 at the center frequency, activate Marker 2 and use Marker Search to find the maximum.
   - Activate Marker 3 and use Marker Search to find the minimum.
   - Save a screen shot of the Log Mag display.
   - Change to Lin Mag display format and save a screen shot.
   - Leave room for screen shots in logbook.

8) Connect the antenna. Place in a location where the antenna and cable will not be disturbed with antenna pointed toward the ceiling. Remember to block diagram(s) of the test set-up.

9) Change the display format to SWR.
   - Adjust the display so that an SWR of 1 is at the bottom and the scale is 1/div.
   - Ensure Marker 1 is at the center frequency.
   - Place Marker 2 at the lowest frequency where the SWR = 1.25.
   - Place Marker 3 at the lowest SWR.
   - Save a screen shot of the SWR display. Leave room for screen shot in logbook.

10) Change the display format to Log Mag. Leave Markers 1-3 in place.
   - Adjust the display so that 0 dB is 1 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.

11) Change the display format to an impedance Smith Chart. Leave markers in place. Save a screen shot. Leave room for screen shot in logbook.

12) Change the display format to Lin Mag. Leave Markers 1-3 in place.
   - Activate Marker 4 and move to lowest frequency where $|S_{11}| = 0.2$.
   - Save a screen shot of the Lin Mag display. Leave room for screen shot in logbook.
   - If no other groups are waiting, power down the VNA.

Analysis

1) Is the antenna usable at the cutoff frequency of the waveguide? Why or why not?
2) How does the lowest frequency where the SWR = 1.25 compare to the waveguide cutoff frequency (express as a multiple of f_c)? How does it compare to the low end of the recommended waveguide frequency range? What percentage of the incident power is reflected?
3) At the lowest frequency where the SWR = 1.25, what is the Log Mag? How does this compare with the commonly used ≤-20 dB specification?
4) How does the lowest frequency where $|S_{11}| = 0.2$ compare to the waveguide cutoff frequency (express as a multiple of f_c)? How does it compare to the low end of the recommended waveguide frequency range? What percentage of the incident power is reflected?
5) Comment on how the input impedance of the antenna changes with frequency.

Summary and Conclusions

- Summarize and draw conclusions from experimental results.

Report

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

Report and logbook due Wednesday, October 30, 2024 at class.