

EE 117B/217B Microwave and Wireless Measurements

Lab 6 Questionnaire - Antenna Measurements

Fall 2026

Group members: _____

Answer each question in the space provided. One combined report per lab group.

1. Antenna Gain Measurements

1.1 Three-Antenna Method

Q1.1.1: Report the measured aperture dimensions of antennas A, B and C and the far-field distance $2D^2/\lambda$ of each at 15 GHz. What separation R did you use? Are all three antenna pairs in each other's far field over the whole sweep?

Q1.1.2: Plot the time-domain response of S_{21} for the pair A–B. Identify the direct-path response, the reflections from the surroundings and the multiply scattered response. At what delay did you expect the multiply scattered response, and where did you observe it? Indicate the gate you used, and explain your choice of gate width.

Q1.1.3: Plot the gated and ungated $|S_{21}|$ (dB) versus frequency for the pairs A–B, A–C and B–C. Comment on the difference between the gated and ungated traces, and on the effect of the absorbers.

Q1.1.4: Write down the three equations of the three-antenna method and solve them. Plot G_A , G_B and G_C (dBi) versus frequency from the gated data. How do G_A and G_B compare with the nominal gain of 15 dBi between 10 and 15 GHz? Report G_A at $f_0 = 9$ GHz.

Q1.1.5: Identify the sources of error in the three-antenna method. Which of them do you think dominated your measurement, and how would you reduce it? Why do the cable losses not appear in the gain calculation?

1.2 Two Identical Antenna Method

Q1.2.1: Plot the gain obtained with the two identical antenna method together with G_A and G_B from Q1.1.4. If the two antennas actually differ in gain by ΔG dB, what is the error in the gain obtained with this method?

1.3 Image Method

Q1.3.1: What is the minimum distance d between antenna A and the plate for the image method to be valid at 15 GHz? Estimate the minimum size of the plate needed (consider

the size of the main beam footprint of the antenna on the plate at the distance d you used). What happens to the measured gain if the plate is too small, or not perpendicular to the boresight?

Q1.3.2: Plot the time-domain response of S_{11} and identify the antenna response and the plate response. Report the distance d computed from the time difference between the aperture and the plate response, and compare it with the value measured with the ruler. Why is time gating essential for this method?

Q1.3.3: Plot the gain of antenna A obtained with the image method versus frequency, together with the results of the three-antenna and two identical antenna methods. Comment on the agreement.

Q1.3.4: Could the image method be used to measure the gain of a narrowband antenna? Of an antenna with a very narrow beam? Explain, considering the time-domain gating and the far-field requirement.

2. Antenna Far-Field Measurements

2.1 Range Setup

Q2.1.1: Report the frequency range, the gain at $f_0 = 9$ GHz and the E- and H-plane half-power beamwidths of the SGH from its datasheet. Report the aperture dimensions and far-field distances of the AUT and the SGH at f_0 , and the range length R you used. Why should the range length typically be at least twice the far-field distance of the SGH?

Q2.1.2: Report the measured cable losses L_{tx} and L_{rx} at f_0 , the estimated gain of the AUT from its aperture area, the expected received power at boresight, the noise floor of FieldFox 2 for a 1 kHz RBW, and the resulting dynamic range of the link.

Q2.1.3: With the AUT polarization vertical, are you measuring the E-plane or the H-plane pattern when the motor rotates? Explain.

2.2 Return Loss of the AUT

Q2.2.1: Plot $|S_{11}|$ (dB) of the AUT from 8 to 10 GHz. Report the frequency of minimum $|S_{11}|$, the -10 dB impedance bandwidth, and the mismatch loss at f_0 . Is the AUT well matched at f_0 ?

2.3 E- and H-Plane Co- and Cross-Polarized Patterns

Q2.3.1: Plot the normalized E-plane and H-plane patterns of the AUT, with the co- and cross-polarized patterns on the same axes, in polar and rectangular (dB versus angle) format.

Q2.3.2: Report the half-power beamwidth, the first-null positions and the first side lobe level in the E- and H-planes.

Q2.3.3: Report the cross-polarization discrimination at boresight in both planes. What limits the cross-polarization level that can be measured on this range?

Q2.3.4: Report P_t , P_r , L_{tx} , L_{rx} , R , G_A at f_0 , and the gain of the AUT obtained from the Friis equation. Compare it with the aperture estimate of Q2.1.2. Estimate the directivity of the AUT from the measured half-power beamwidths and the efficiency of the array. Is the measured value the gain or the realized gain? Convert it to the other using the S_{11} of Q2.2.1. What are the main sources of error in this gain measurement?

3. Antenna Measurements Using the Keysight CATR Chamber

3.1 Connecting the FieldFox to the Chamber

Q3.1.1: From the datasheet of the Eravant SAR-2013-282F-E2 horn, report its frequency range, gain, E- and H-plane half-power beamwidths and aperture dimensions. Estimate the far-field distance $2D^2/\lambda$ of the AUT at 25 GHz and compare it with the size of the chamber. Explain how the CATR makes it possible to measure the far-field pattern inside the chamber.

3.2 Mechanical Boresight Alignment and Positioning

Q3.2.1: Report the motor offsets found by the mechanical boresight alignment. What do they represent?

3.3 Measurement Setup and Gain Measurement

Q3.3.1: Plot the measured gain versus azimuth from -30° to $+30^\circ$, and report the boresight gain of the AUT. Explain why, with **Enable** and **Subtract Horn** checked, the measured amplitude is the gain of the AUT. Compare the boresight gain with the datasheet, and explain the small difference (consider the measurement frequency relative to the specified band of the horn, and the 2.4 mm-to-2.92 mm adapters, which are in neither the FieldFox calibration nor the chamber calibration).

3.4 Principal-Plane Pattern Cuts

Q3.4.1: Identify the E-plane and H-plane cuts and plot them (gain in dBi versus azimuth). Why must the feed roll be set to 90° together with the roll for the second cut? Report the half-power beamwidths and side lobe levels, and compare them with the datasheet. Estimate the directivity from the half-power beamwidths, and compare it with the measured gain.

3.5 2D Radiation Pattern

Q3.5.1: Make a 2D polar plot of the measured pattern (θ radial, ϕ angular, amplitude in dB as color) and report the duration of the sweep. Explain the shape of the pattern using the Ludwig-3 definitions, in particular near $\phi = 90^\circ$, given that the vertical feed port measures E_ϕ of the AUT. Does the cut at $\phi = 0^\circ$ agree with the corresponding principal-plane cut of Q3.4.1?