EE 117B/217B Microwave and Wireless Measurements

Lab 1 Questionnaire - Introduction to Vector Network Analyzers

Fall 2026

Group members: ____________________________________

Answer each question in the space provided. Questions marked [**EE 217B only**] are required for 217B students and optional for 117B students. One combined report per lab group.

1. Familiarization with the Network Analyzer

1.1 Initial Setup

Q1.1.1: Magnitude of S_{21} in dB at 0.1 MHz?

Q1.1.2: Magnitude of S_{21} in dB at 100 MHz?

1.2 Noise Reduction Techniques

Q1.2.1: Plot of HPF response after averaging 8 traces.

Q1.2.2: Magnitude of S_{21} in dB at 0.1 MHz with 8 averages?

Q1.2.3: Magnitude of S_{21} in dB at 100 MHz with 8 averages?

Q1.2.4.A: Magnitude of S_{21} in dB at 0.1 MHz for VNA averaging set to 1, after manually averaging 20 observations?

Q1.2.4.B: Magnitude of S_{21} in dB at 0.1 MHz for VNA averaging set to 8, after manually averaging 20 observations?

Q1.2.4.C: Does the result follow your expectation? If not, why is there still a disagreement?

Q1.2.4.D: What is the difference between you manually averaging vs. the VNA's averaging?

Q1.2.5: Plot of the HPF `Data - Mem` trace after reconnecting the HPF, with the marker at 100 MHz.

Q1.2.6: Plot of the `Data - Mem` trace after 16 averages, with the marker at 100 MHz.

Q1.2.7: Plot of the `Data - Mem` trace for the repeatability test with the stop frequency raised to 10 GHz, with the marker at 10 GHz. Why is the repeatability worse at higher frequencies?

Q1.2.8: What did you notice on the `Data - Mem` plot when the SMA cable was lightly touched? Did the trace return to the noise floor when you released it? Based on this, comment on the phase stability of the cable.

Q1.2.9: S_{21} plot after setting IF BW to 100 Hz, with markers at 0.1 MHz and 100 MHz and the marker table on.

Q1.2.10: How much noise suppression was achieved compared to the case when averaging was used? Does this match your expectation?

Q1.2.11: Why does the sweep arrow move across the screen for the sweep time and then stop at the end for the same amount of time?

1.3 Phase Response

Q1.3.1: What is the phase difference between 0.2 GHz and 0.8 GHz with the electrical delay set to zero?

Q1.3.2: What electrical delay value τ_d flattens the phase trace with the cable connected directly between the two ports?

Q1.3.3: With that electrical delay applied and the HPF reconnected, plot the phase response and record the phase difference between 0.2 GHz and 0.8 GHz. Is the phase response linear with frequency?

Q1.3.4: Plot the group delay versus frequency, extracted from the saved phase response data.

2. Calibration

2.1 Full 1-port Calibration

Q2.1.1: Smith Chart of the short standard at the end of the calibrated SMA cable. Comment on the result.

Q2.1.2: Smith Chart with correction switched off, plotted against the stored corrected trace (data and memory). Compare the two.

Q2.1.3: [**EE 217B only**] Using the raw S1P data for the short, open, and matched load, solve for E_D, E_S, and E_R and correct the raw response of the test device (female short connected to the SMA cable). Plot the manually corrected response against the internally corrected response in one Smith Chart. Also plot the three error factors vs. frequency.

2.2 Full 2-port Calibration

Q2.2.1: Verification of the 2-port calibration. With the thru connected, plot the S_{21} magnitude and the S_{11} and S_{22} magnitudes over the calibrated span and report the worst-case values. Then plot the S_{11} Smith Chart traces for the open and short standards on Port 1. Does the calibration meet your expectations?

3. Isolator, Filters, and Attenuator

3.1 Isolator

Q3.1.1: What is the minimum insertion loss at the center frequency of the operating band?

Q3.1.2: What is the isolation at the center frequency of the operating band?

Q3.1.3: What is the input matching bandwidth using the criterion $S_{11} < -20$ dB? Report the lower and upper cutoff frequencies.

Q3.1.4: Is the VSWR response consistent with the bandwidth obtained from the S_{11} measurement? What VSWR value corresponds to $S_{11} = -20$ dB?

Q3.1.5: Plot all four S-parameters (log-mag) in one figure by extracting the S2P file. Is this device reciprocal?

Q3.1.6: With two isolators connected back to back, is the resulting device any different from an attenuator? Is it reciprocal?

3.2 Bandpass Filter

Q3.2.1: What is the center frequency and the minimum insertion loss within the passband?

Q3.2.2: What is the 3-dB bandwidth? Report the lower and upper 3-dB cutoff frequencies.

Q3.2.3: What is the stopband attenuation at 4.3 GHz and 6.8 GHz? How does it compare with the datasheet table?

Q3.2.4: What is the roll-off on both sides of the passband (dB/GHz) between the 3-dB cutoff frequency and the corresponding 20-dB attenuation frequency?

Q3.2.5: What is the input matching bandwidth using the criterion $S_{11} < -10$ dB?

Q3.2.6: Is the VSWR response consistent with the measured input matching bandwidth? How does the passband VSWR compare with the datasheet value (1.3 typ., 2.1 max.)?

Q3.2.7: Plot all four S-parameters (log-mag) in one figure by extracting the S2P file.

3.3 Attenuator

Q3.3.1: What is the average attenuation over the measured frequency range, and what is the peak-to-peak flatness?

Q3.3.2: What is the worst-case input return loss over the band? How does it compare with the isolator and the filter?

Q3.3.3: Compare the measured S_{21} and S_{12} responses. Is the attenuator reciprocal?

Q3.3.4: Compare the measured characteristics of the attenuator with those of the isolator. What is the fundamental difference between these two components?

4. Amplifier

Q4.1.1: What are the gain, S_{21} bandwidth, input bandwidth, output bandwidth, reverse isolation, and DC power consumption of the amplifier?

Q4.1.2: Plot your measured S-parameters against the manufacturer's S2P data (downloaded from the Mini-Circuits website).

Q4.1.3: Extract and plot the group delay versus frequency from the measured S-parameters.

Q4.1.4: [**EE 217B only**] Plot the Rollett stability factor (K) as a function of frequency and carry out the $K - \Delta$ test. Is this amplifier unconditionally stable?

Q4.1.5: [**EE 217B only**] Plot the input and output stability circles on a Smith Chart and identify the stable and unstable regions (see Appendix C of the lab manual).

5. Directional Coupler

Q5.1.1: Plot the insertion loss, directivity, coupling, and return loss as a function of frequency over 0.5–8.0 GHz. Compare each against the datasheet specifications.

Q5.1.2: Consistency checks.

- *Redundancy:* plot the two independently measured versions of each of S_{11}, S_{22}, and S_{33} on the same axes and report the worst-case disagreement in dB. What does this tell you about connector repeatability and residual calibration error?
- *Reciprocity:* plot $|S_{21}|$ against $|S_{12}|$, $|S_{31}|$ against $|S_{13}|$, and $|S_{32}|$ against $|S_{23}|$, and report the worst-case deviation.

6. Dielectric Constant of a Liquid

6.2 Instrument Setup and Port 1 Calibration

Q6.2.1: Did the `Data - Mem` trace return to the noise floor after you touched and released the probe cable? Report the worst-case deviation you observed while flexing the cable.

Q6.2.2: Explain in your own words why the 1-port OSL calibration cannot change the extracted ε^*.

6.3 Measuring the Three Calibration Standards

Q6.3.1: What was the temperature of the distilled water standard?

Q6.3.2: Plot the magnitude of S_{11} for the short, air, and water standards on one set of axes, and their loci on one Smith Chart.

Q6.3.3: All three standards have $|S_{11}|$ close to unity at low frequency. Explain physically why this is expected, and why the three curves nevertheless separate as frequency increases.

6.5 Data Processing

Q6.5.1: Plot ε' and ε'' of isopropyl alcohol from 0.1 GHz to 6 GHz, showing all three trials on the same axes.

Q6.5.2: Tabulate ε' and ε'' at 0.5, 1, 2, and 3 GHz.

Q6.5.3: Process `air_check.s1p` as an unknown and plot the recovered ε^*. How close to $1 - j0$ is it, and over what frequency range?

Q6.5.4: Plot the maximum deviation of any of your three IPA trials from their mean, normalized by $|\varepsilon^*|$, as a function of frequency.

Q6.5.5: Above roughly 3–4 GHz your extracted ε'' degrades and may go negative, which is unphysical. Which assumption in the model breaks down, and why does it break down at high frequency rather than at low frequency?

Q6.5.6: Bench check-off. All components disconnected and returned to the box as received.

Instructor signature: ______________________________ Date: ______________