EE 117B/217B Microwave and Wireless Measurements

Lab 3 Questionnaire - Introduction to Spectrum 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. Resolving Closely Spaced Signals

1.1 Characterizing and Filtering the FieldFox Internal Source

Q1.1.1: With the 1 GHz low-pass filter on the FieldFox internal source and the RBW reduced to 10 kHz, what is the strongest harmonic you can see and at what frequency?

Q1.1.2: Why are the harmonics at higher frequencies not attenuated as much? Support your answer with the S_{21} of the filter measured in VNA mode.

1.2 Stepping Through a Measurement of Two Equal Amplitude Signals

Q1.2.1: After adjusting S1 (VSG) so that its marker reading matches that of S2 (FieldFox), what is the amplitude setting on each of the two sources, and what is the amplitude of each of the two peaks on the SA?

Q1.2.2: Plot the display for the two tones separated by 1.2 MHz, with RBW = 100 kHz and VBW = 10 kHz.

Q1.2.3: Plot the display with the RBW changed to 3 MHz and the span increased to 20 MHz, where the two signals can no longer be distinguished.

Q1.2.4: What is the maximum RBW that still resolves the two signals, with the dip at least 3 dB below the peaks? Include the plot.

Q1.2.5: With the VBW increased to 1 MHz, the dip at 1 GHz becomes unstable. Explain why.

Q1.2.6: Report the peak value measured with the trace in `MaxHold`. Explain why the dip disappears in `MaxHold` and becomes very deep in `MinHold`.

Q1.2.7: With RBW = 100 kHz, VBW = 100 kHz, a 100 MHz span and 101 points, the two signals again partially intersect — but now the dip does not fluctuate, even with the VBW set to 1 MHz. Explain why.

Q1.2.8: With a single 1 GHz tone, a 100 MHz span and the RBW reduced in steps from 1 MHz, at what RBW does the analyzer switch from STEP to FFT mode?

Q1.2.9: As the RBW is lowered from 1 MHz to 1 Hz one decade at a time, why does the noise floor drop? Tabulate the noise floor at each RBW and state whether the drop per decade meets your expectations, in both STEP and FFT modes.

Q1.2.10: [EE 217B only] Report the shape factor of the IF filter (the ratio of the 60 dB to the 3 dB bandwidth) in both STEP and FFT modes, along with the span, RBW and VBW settings you used.

2. Harmonic Distortion

2.1 Fast Harmonic Measurement: Procedure A

Q2.1.1: The harmonic marker levels did not change when the RF attenuation was increased from 15 dB to 25 dB. Why does that show the harmonics are coming from the source and not from the analyzer's own mixer?

Q2.1.2: Why did the noise floor apparently go up when the attenuation value was increased?

Q2.1.3: Plot the display (200 MHz – 1 GHz) with the fundamental raised to the reference level.

Q2.1.4: (Method 1) Report the level of the second, third and — if visible — fourth harmonics relative to the fundamental in dBc, the harmonic distortion due to each, the resulting THD, and the S/N of each measurement.

Q2.1.5: With the stop frequency extended to show two more harmonics, report the harmonic distortion from each harmonic and the THD. What differences do you observe in the THD between the 3-harmonic and 5-harmonic cases, and how do you explain them?

Q2.1.6: (Method 2) With the amplitude units set to volts, report the voltage of the fundamental and of each harmonic, and the resulting percent of distortion. Compare it with your Method 1 result.

2.2 Accurate Harmonic Measurement: Procedure B

Q2.2.1: Plot the display of the fundamental in the reduced span, with the signal moved to the top of the graticule.

Q2.2.2: Measuring each harmonic in a narrow span and RBW, report the level and the SNR in dB of every harmonic up to the sixth, the harmonic distortion due to each, and the THD. Compare with the values found using Procedure A.

Q2.2.3: Using the amplitudes of the harmonics in volts, compute the total percent of harmonic distortion.

2.3 Very Accurate Harmonic Measurement at Lower Frequencies: Procedure C

Q2.3.1: [**EE 217B only**] Using the lock-in amplifier setup shown by the instructor, measure the harmonic distortion of the source. Report the level of each harmonic you can detect and the resulting THD. Compare the weakest harmonic you can measure this way with the weakest one Procedure B could resolve on the spectrum analyzer, and explain where the difference comes from.

3. 1 dB Compression and IIP3

3.1 Part A: Small-Signal Gain

Q3.1.1: Report the through reference P_{ref}, the amplifier output P_{out} at -30 dBm input, and the small-signal gain G. How does G compare with the datasheet value?

3.2 Part B: 1 dB Compression Point

Q3.2.1: Tabulate the input power, the output power corrected for the loss of the line, and the gain at each step. Plot P_{out} versus P_{in} with the straight line extrapolated from the linear region, and report the input and output 1 dB compression points $P_{\mathrm{1dB}}^{\mathrm{in}}$ and $P_{\mathrm{1dB}}^{\mathrm{out}}$.

3.3 Part C: Two-Tone Intermodulation of the Test Setup (No Amplifier)

Q3.3.1: Does terminating the other two ports of the power combiner change the result? What does this tell you about the isolation between the combiner ports?

Q3.3.2: Plot the two-tone display (tones at 0.999 and 1.001 GHz) and report the level of the IM3 products at 0.997 and 1.003 GHz relative to the two tones.

Q3.3.3: As the SA input attenuation is stepped up, does the IM3 level change, and at what attenuation does it stop changing? If the SA is not contributing to the IM3, where does the residual IM3 come from? Report the residual setup IM3 level — your distortion floor.

3.4 Part D: Amplifier Third-Order Intermodulation and IIP3

Q3.4.1: Before sweeping the power, you compared the IM3 products with the amplifier in place against the residual setup IM3 from Part C. Explain why this check is necessary.

Q3.4.2: Plot P_{fund} and P_{IM3} versus the per-tone input power P_{in} on the same axes, with straight-line fits to the linear-region points of each trace extrapolated to their intersection. Report the fitted slopes, IIP3 and OIP3. Confirm with a single mid-range point that IIP3 $=$ $P_{\mathrm{in}} + \Delta P/2$ and OIP3 $=$ IIP3 $+\, G$, with G from Part A.

Q3.4.3: Over what range of input power do the fundamental and IM3 traces actually follow the ideal 1 dB/dB and 3 dB/dB slopes? Explain what happens to each trace as the amplifier approaches compression, and why only the linear-region points may be used in the extrapolation.

Q3.4.4: By how many dB does your measured IIP3 exceed $P_{\mathrm{1dB}}^{\mathrm{in}}$ from Part B? Compare this with the commonly cited rule of thumb ($\sim$9.6 dB for an ideal third-order-limited device) and comment on any difference.

4. External Millimeter-Wave Harmonic Mixing

Q4.1.1: With the analyzer in Frequency Extension mode and the center frequency at 72 GHz, record the displayed power of the signal, and give the corresponding power at the PSAX waveguide flange after accounting for the module's ≈10 dB of conversion gain.

Q4.1.2: The frequency of the image response changes when you change the analyzer's center frequency, while the true 72 GHz response stays fixed. Explain why, using the expression for the displayed frequency of a response converted through harmonic n. What does the behaviour tell you about the IF the instrument is using?

Q4.1.3: With the center frequency set to 77 GHz, record the image frequency. From it, estimate the IF and the LO frequency the instrument is applying. Show your calculation.

Q4.1.4: Repeat Q4.1.3 with the center frequency set to 79 GHz. Do you get the same IF and LO? Comment.

Q4.1.5: Report the frequency and amplitude of one of the further (weaker) image or spur responses you found, and use the displayed-frequency relation to work out which harmonic n produced it.

Q4.1.6: In ordinary SA mode, what LO frequency is required to place a 72 GHz RF signal at an IF of 1 GHz with $N = 6$? Show the calculation, then report the signal power measured at 1 GHz with that LO applied from the FieldFox internal source.

Q4.1.7: What LO frequency places the same 72 GHz signal at 1 GHz through the opposite sideband at $N = 6$? Report the measured power. Is it the same as in Q4.1.6? Explain why or why not.

Q4.1.8: What LO frequency receives the 72 GHz signal on the lower sideband of $N = 7$ at an IF of 1 GHz? Report the measured power, how far below the $N = 6$ response it sits, and what that tells you about the $\times 6$ multiplier chain inside the PSAX module.