

EE 117B/217B Microwave and Wireless Measurements

Lab 4 Questionnaire - Noise and Phase Locked Loops

Fall 2026

Group members: _____

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

1. Noise Figure Experiments

1.1 Calibrating the FieldFox NF Mode

Q1.1.1: Record the receiver's own calibrated noise figure at 100 MHz and 1000 MHz.

Q1.1.2: The calibrated noise figure of the receiver should be around 0 dB. Why is it not exactly zero?

Q1.1.3: Plot the resulting display of the calibrated noise figure over 10 MHz – 18 GHz.

1.2 Measuring a DUT

Q1.2.1: Is the measured noise figure of the 10 dB attenuator as expected? Plot the saved NF versus frequency.

Q1.2.2: Plot the measured noise figure and gain of the RF amplifier versus frequency. How do they compare with the datasheet?

Q1.2.3: Plot the amplifier gain measured from S_{21} and the gain obtained from the NF-mode measurement on the same axes. Compare them.

Q1.2.4: From the measured gain and noise figure, compute and plot the noise measure of the amplifier over the frequency range.

Q1.2.5: Plot the measured noise figure and gain of the band pass filter (4.9 GHz – 6.2 GHz) over the same frequency range.

1.3 Noise Figure of Cascaded Stages

Q1.3.1: Plot the measured noise figure of the attenuator→amplifier cascade and of the amplifier→attenuator cascade. Comment on the differences.

Q1.3.2: Compute the noise figure of the two cascades from Friis's equation. Plot the computed and measured results together. Do they agree?

Q1.3.3: Plot the measured noise figure of the cascade BPF→amplifier→attenuator and compare it with the value computed from the cascaded noise figure formula.

Q1.3.4: Which order of the three stages minimizes the noise figure over 10 MHz – 18 GHz, and why? Plot the measured noise figure in this order together with the value computed from Friis's equation.

Q1.3.5: Do your computed results lie within the uncertainty bars of the measurements? Comment.

1.4 Computing the Noise Figure Using the Gain Method

Q1.4.1: With RBW = 1 kHz, is the Equivalent Noise Bandwidth also 1 kHz? Explain.

Q1.4.2: What value does the noise marker read with the amplifier unpowered and its input terminated? What does this value represent?

Q1.4.3: When the amplifier is turned on, does the marker reading change? If not, why not? What output noise power do you expect from the amplifier?

Q1.4.4: With the amplifier disconnected and Port 2 terminated, what is the noise power spectral density, and how does it compare with the earlier measurement? What is the noise figure of the spectrum analyzer itself? Why would the gain method fail to measure the noise figure of this single amplifier?

Q1.4.5: Report the measured gain of the two-amplifier cascade at 10 GHz.

Q1.4.6: With the input terminated, what does the noise marker read at 10 GHz for the two-amplifier cascade? Does the marker value change when the DC supplies are turned on and off?

Q1.4.7: Using the gain and the output noise power, calculate the noise figure at 10 GHz using the gain method. Does it agree with the cascaded noise figure calculation for two amplifiers?

2. VCO and PLL Experiments

2.1 DC Characterization of the VCO

Q2.1.1: Tabulate and plot f_{VCO} versus V_{tune} (2 V – 13 V in 0.5 V steps).

Q2.1.2: Report the tuning range: minimum frequency, maximum frequency and total span in GHz.

Q2.1.3: Compute and plot K_{VCO} as a function of tuning voltage. Is it constant across the tuning range, or does it vary?

Q2.1.4: Report the average K_{VCO} and compare it with the 150 MHz/V value in UG-383. State clearly whether your value refers to the VCO output (EXT_VCOOUT) or to the VCO/2 signal seen by the phase detector.

Q2.1.5: Why does the trace become wider with time in Max Hold? Report the width of the trace after a few minutes.

Q2.1.6: Report the approximate peak-to-peak frequency variation of the free-running VCO.

Q2.1.7: Do you see the frequency change when your finger hovers close to the VCO? Explain why it changes without touching.

Q2.1.8: What happens when you gently touch the VCO? Why does the frequency always decrease when hovering or touching?

2.2 VCO Phase Noise

Q2.2.1: Report the peak signal power with (span 1 GHz, RBW 10 kHz) and (span 10 MHz, RBW 100 Hz). Why did it drop?

Q2.2.2: Report the noise spectral density at 10 kHz, 100 kHz and 1 MHz offsets.

Q2.2.3: Report the phase noise of the VCO in dBc/Hz at these offsets, and show your calculation.

2.3 Hold-In Range and Lock Time

Q2.3.1: With the PLL locked at 12 GHz, is the signal stable? What happens when you bring your finger close to the VCO this time?

Q2.3.2: Report the VTUNE voltage at 11 GHz, 11.5 GHz, 12 GHz and 12.5 GHz and plot them on your earlier V_{tune} versus frequency plot. Do they match your expectations from the K_{VCO} you measured?

Q2.3.3: Plot the spectrum at the point of lock failure and explain why it looks the way it does. What do you see on the VTUNE signal?

Q2.3.4: Plot the spectrum after one more 5 MHz step up. Is the PLL locked? If yes, how come it is locked at a higher frequency than before? If not, why is the spectrum so much cleaner? What do you see on VTUNE?

Q2.3.5: Plot the open-loop trace after increasing the frequency in 20 MHz steps. Why do the spurs exist?

Q2.3.6: Plot the spectrum and VTUNE when you step down by 5 MHz to a frequency where the PLL was previously locked. Why can you not lock the PLL?

Q2.3.7: Report the results of decreasing the frequency from a locked state in 5 MHz steps. What is the hold-in range?

Q2.3.8: Is the hold-in range different with 1 MHz steps? Report your final hold-in range as the actual output frequency range.

Q2.3.9: Report the pull-in range (actual output frequency range), including the upper and lower limits.

Q2.3.10: Include the oscilloscope capture of the V_{tune} transient for a 10 MHz step. What is the lock time (time to reach 90% of the final value)?

Q2.3.11: Include the oscilloscope captures for 100 MHz and 200 MHz steps from 6000 MHz. Do you see cycle slipping? Explain why, and compare the two cases.

Q2.3.12: Report the lock-in range (actual output frequency range).

3. PLL Phase Noise

Q3.1: Why is the center frequency of the PLL not exactly 12 GHz?

Q3.2: Report the peak signal power with span 1 MHz and RBW 100 Hz. Why did it *not* drop this time, as opposed to the free running VCO?

Q3.3: Report the noise spectral density at 10 kHz, 100 kHz and 1 MHz offsets.

Q3.4: Report the phase noise of the PLL in dBc/Hz at these offsets.

Q3.5: Compare the phase noise of the PLL with that of the free running VCO (Q2.2.3) at the same offsets and explain the differences.