UCSD MAS WES268A - Lab 4 Report

06DEC2025

PREPARED BY:

Joshua Hoang
Ryan Shimizu

Contents

1 Part 1: Channel Estimation using a PN Sequence

1.1 Impulse Response Estimation of a Multipath Channel

1.1.1 Basic Measurements

5. - Insert

6. -

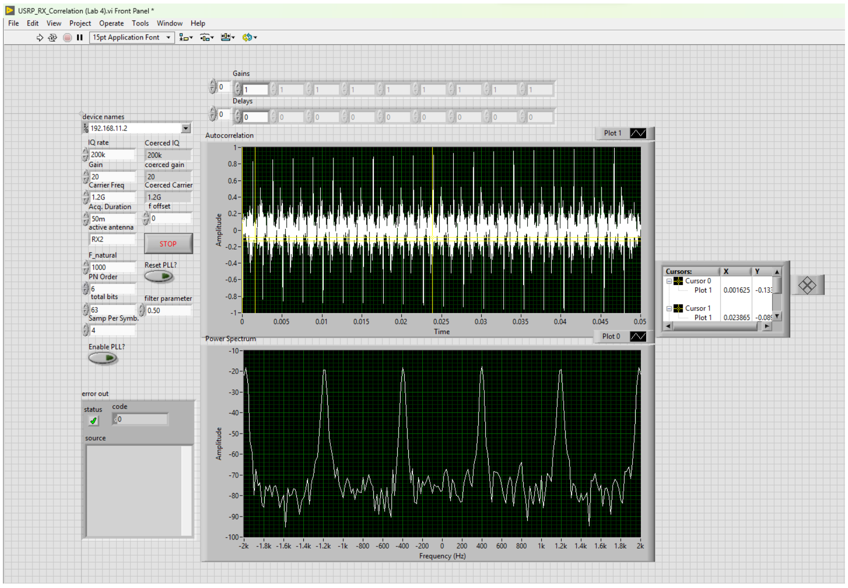

Figure 1: 1.1.1.5/6 - Frequency at DC Component and PN sequence spectrum

7/8. -

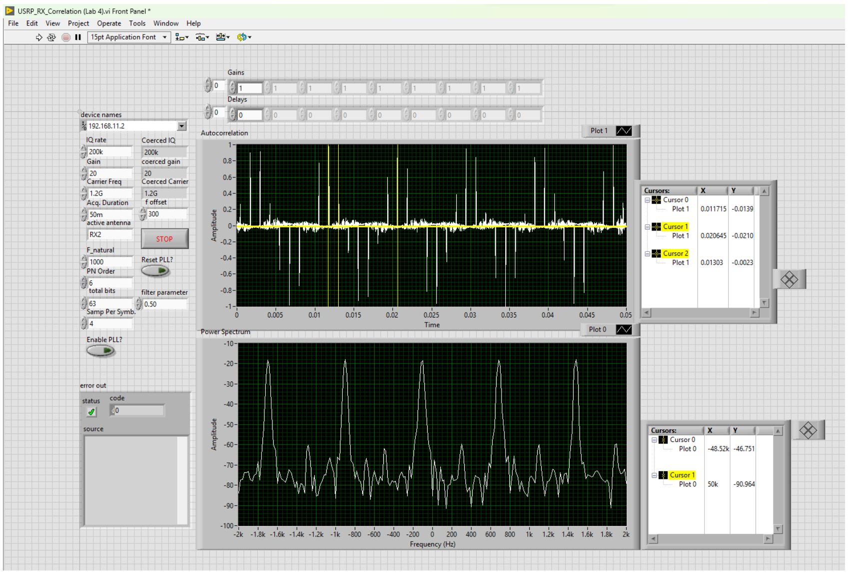

Figure 2: 1.1.1.7/8 - Period of Delta spikes of autocorrelation graph

9/10. -

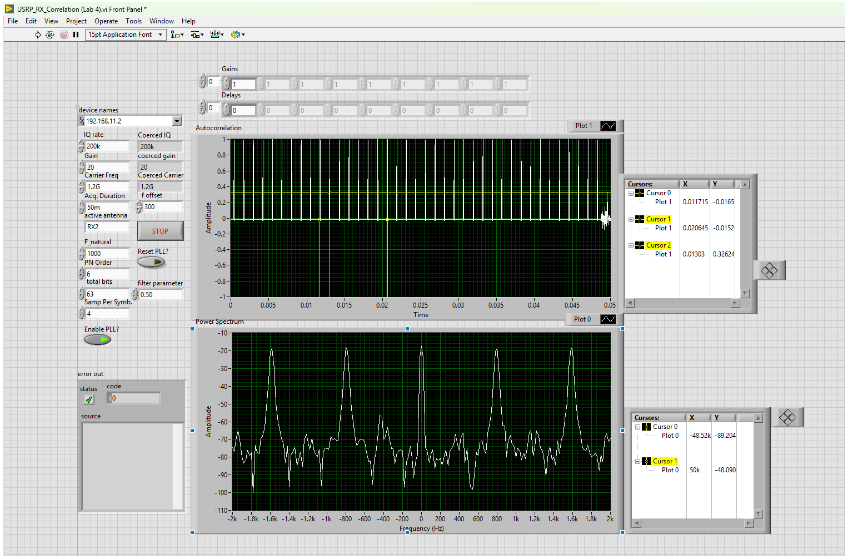

Figure 3: 1.1.1.9/10 - Period of Delta spikes of autocorrelation graph

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1.1.2 Fading Measurements and Equalization

2. -

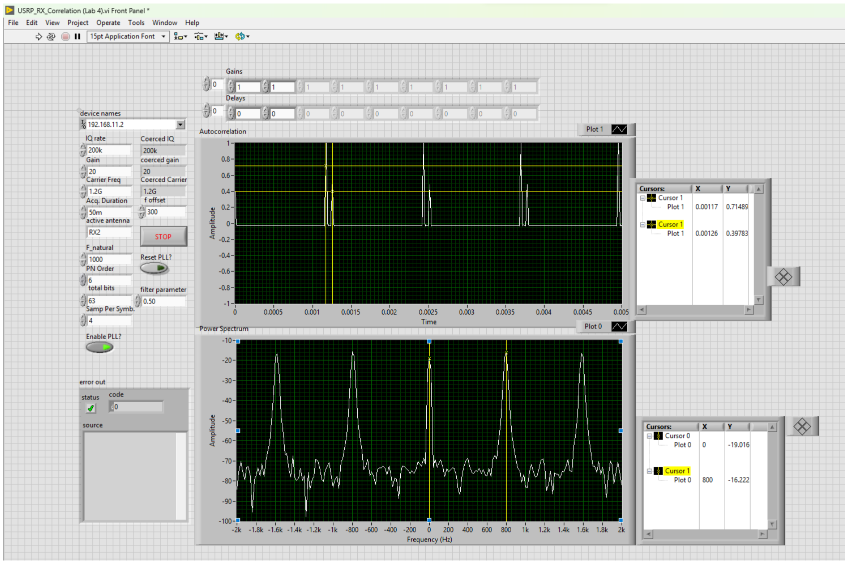

Figure 4: 1.1.2.2 - Gains of Direct and Echo Path Terms

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3. -

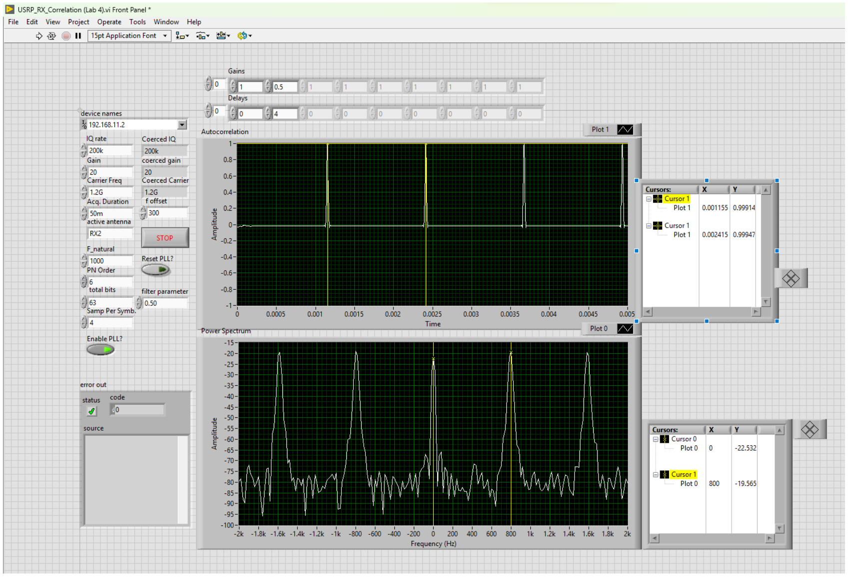


Figure 5: 1.1.2.3 - Gains of Direct and Echo Path Terms using fading paragrameters at receiver

4. - Insert

5a. -

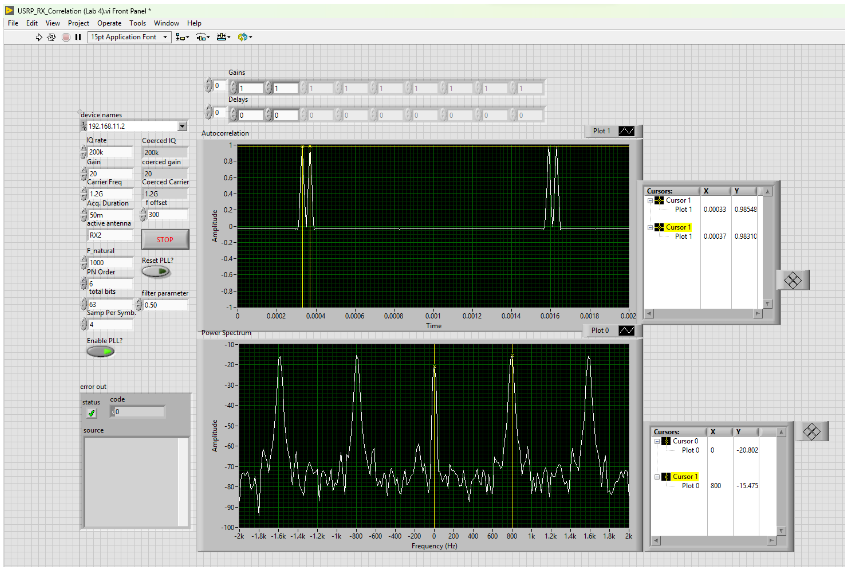


Figure 6: 1.1.2.5a - Gains of Direct and Echo Path Terms, PN Order of 6

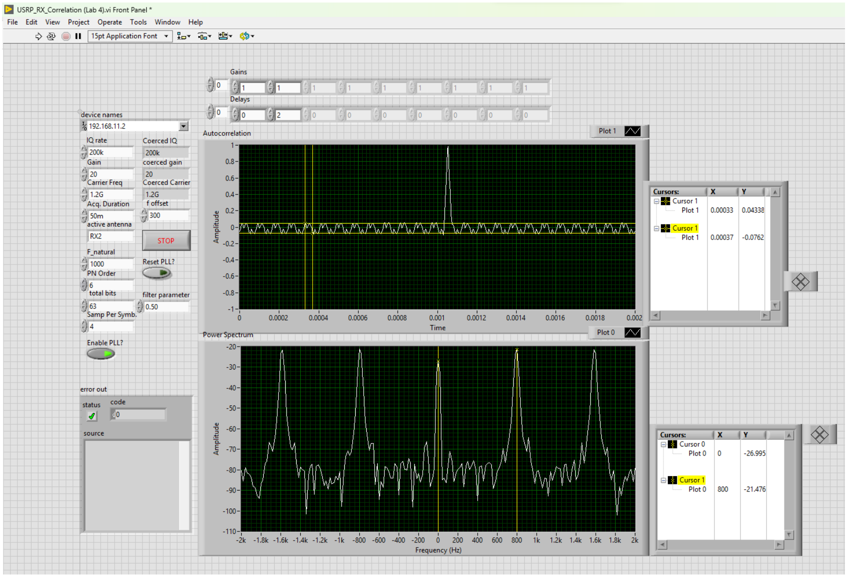


Figure 7: 1.1.2.5a - Gains of Path Terms using transmitter fading parameters, PN Order of 6

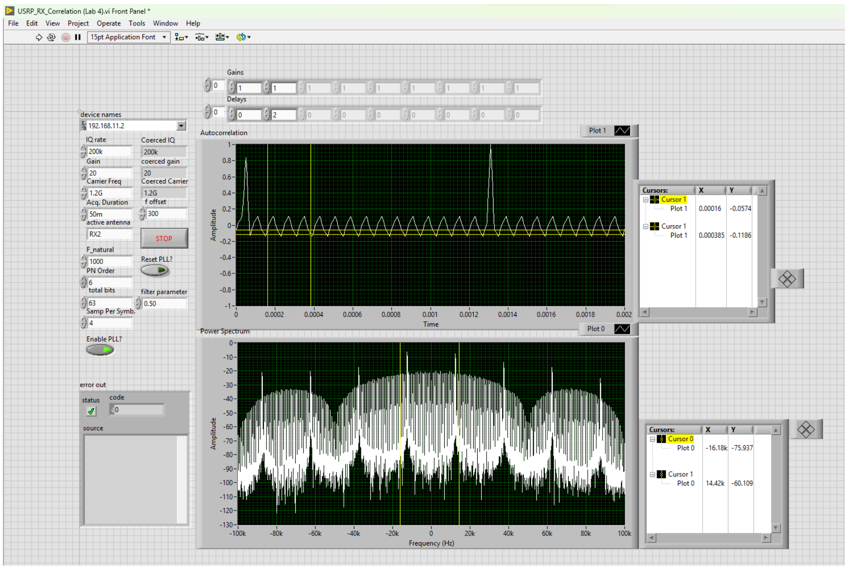


Figure 8: 1.1.2.5a - Gains of Path Terms using measured fading parameters, PN Order of 6

5b. -

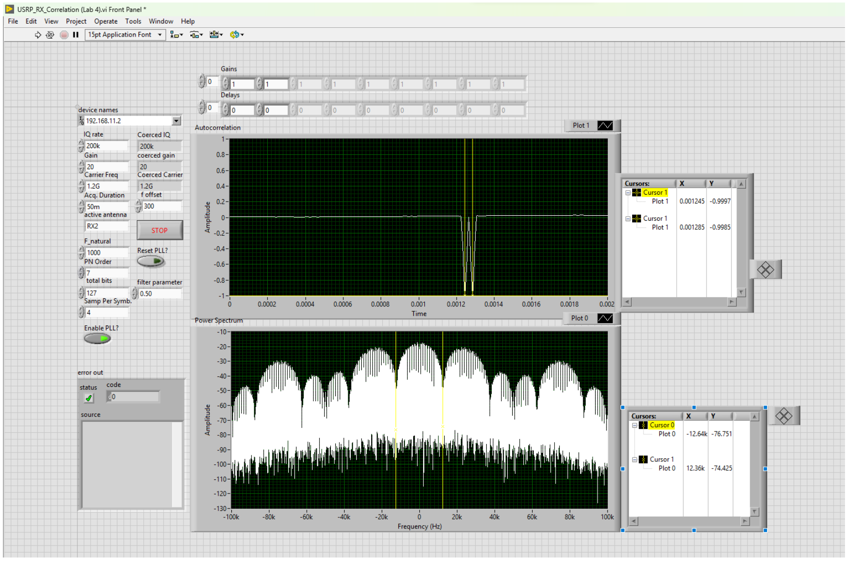


Figure 9: 1.1.2.5b - Gains of Direct and Echo Path Terms, PN Order of 7

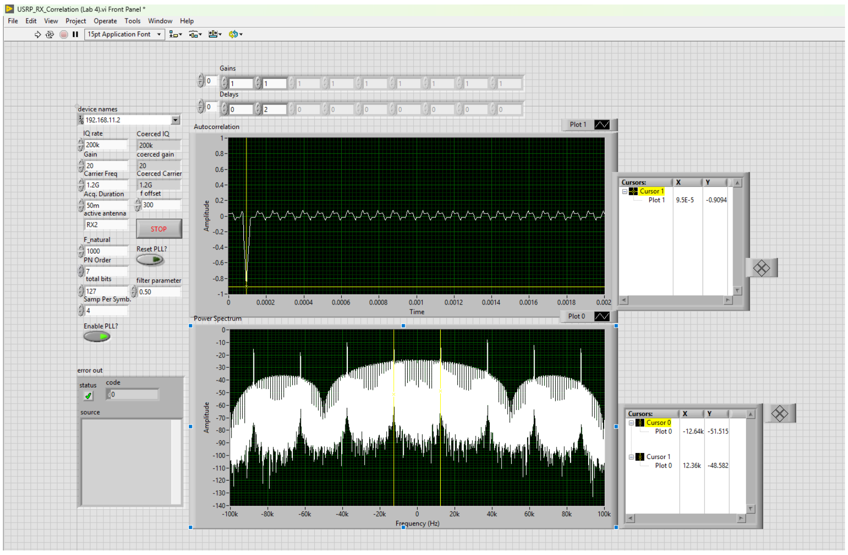


Figure 10: 1.1.2.5b - Gains of Path Terms using transmitter fading parameters, PN Order of 7

6. - Insert
7. - Insert
8. - Insert

1.2 Write-Up

1.2.1

Describe how you would create an FIR approximation of the equalization filter $g(n)$ denoted g(n). Assuming the following H(z):

$$H(z) = 1 + Az^{-T}$$

$$G(z) = \frac{1}{1 + Az^{-T}}$$

You may assume that $|A| < 1$, and T is a positive integer. Hint: What can you say about $g(n)$ for large values of $n > N$.
Answer. Insert

Now, for values $A = 0.5$ and $T = 4$, find a $\hat{g}(n)$.
Answer. Insert

1.2.2

Based on your observations from this lab, describe the relationship between invertibility of a channel $H(z)$ in respect to its poles and/or zero locations. In other words, what kind of channels $h[n]$ are invertible (i.e. does a causal equalizer filter $g[n]$ exist?) and non-invertible?
Answer. Insert

1.2.3

a) Suppose that we wish to estimate the channel using a particular training sequence called the "WES" sequence. All you know about this code is that it has very good auto-correlation properties $\Sigma w(k)w^*(n+k) = \delta(n)$ and the following quasi-periodic property:

$$w(n) = \begin{cases} w(n+mL) & 0 \le m \le 9, \\ 0 & otherwise \end{cases}$$

Effectively, the "WES" sequence is a length L sequence that repeats itself 10 times. Now, assuming the input to your receiver is the "WES" sequence $w(n)$ with a frequency offset of f_0

$$x(n) = w(n)e^{j2\pi f_0 n}$$

Find the cross-correlation between the received sequence $x(n)$ and the "WES" sequence $w(n)$, denoted $r_{xw}(n)$

$$r_{xw}(n) = \sum_k x(n+k)w^*(k)$$

for values of $n = \{0, L, ..., 9L\}$, you may assume that the term A is a constant where

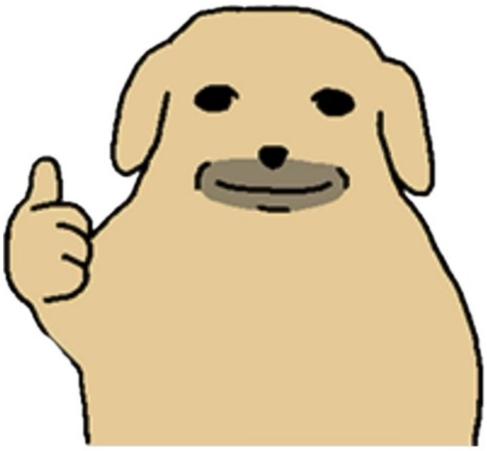
$$A = \sum_k |w(k)|^2 e^{j2\pi f_0 k}$$

Answer. Insert

b) Using your calculation of $r(0)$, and the fact that $|w(k)|^2 = 1$, comment on the effect that frequency offset has on the magnitude of the cross-correlation.
Answer. Insert

c) Explain how you would calculate the frequency offset from your calculated values of $r_{xw}(mL)$.
Answer. Insert

d) What is the maximum frequency offset f_{max} that can be tracked using the cross-correlation approach and the "WES" code $w(n)$ of length L (Hint: Think of the nyquist sampling theorem).
Answer. Insert



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