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Date: April 10, 2025

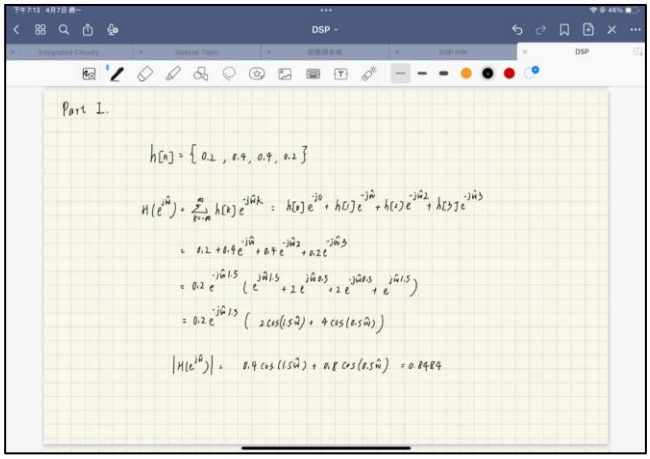
Subject: Undergraduate Project – FIR Filter Frequency Response and Sampling Effects

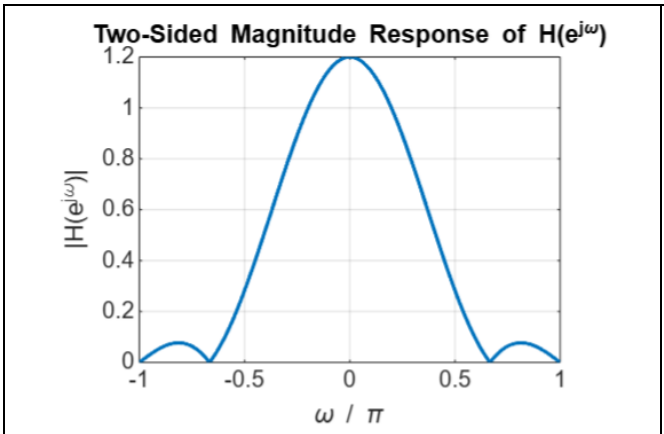
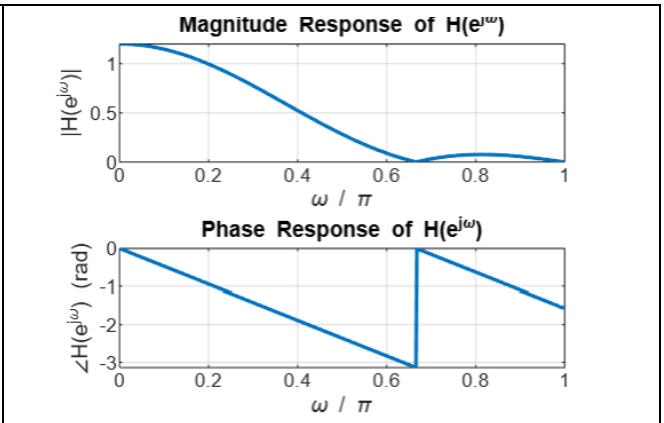
A. Introduction

In this project, I explored how an FIR filter responds to different frequencies and how well it can filter out a 1200 Hz signal. By trying different sampling rates, I found that the choice of fs affects how effective the filter is at removing high-frequency components.

B. Summary

Part I Frequency Response Diagram of FIR Filter

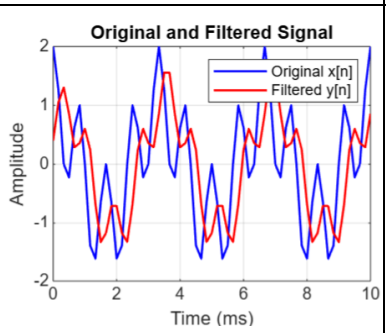
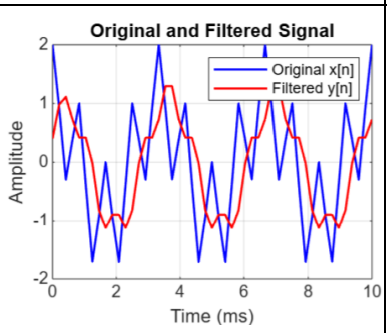
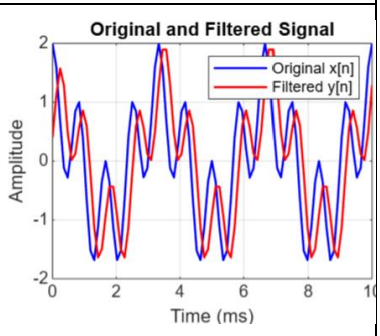
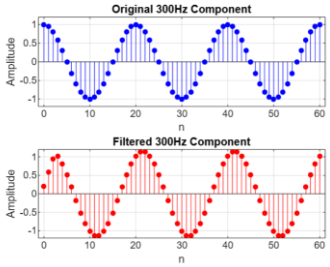
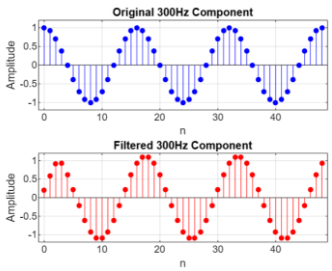
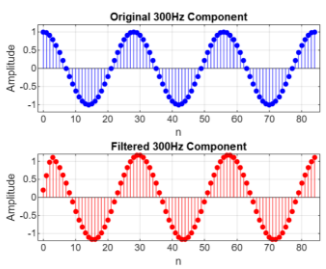
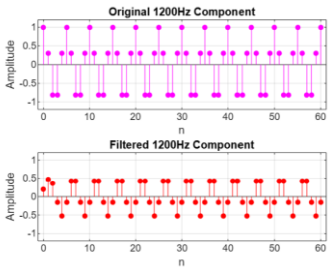
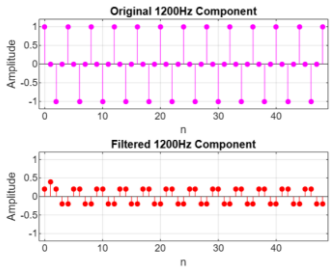
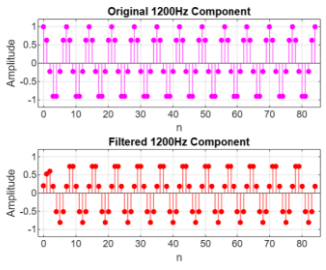
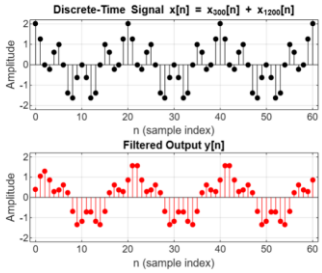
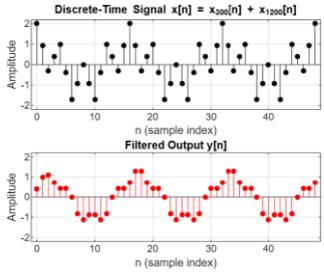
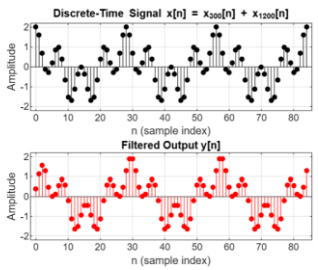


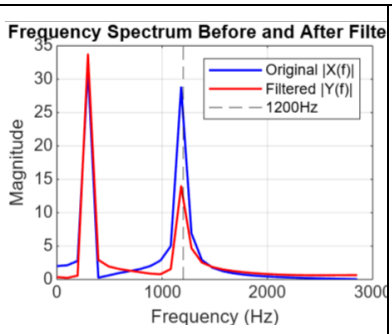
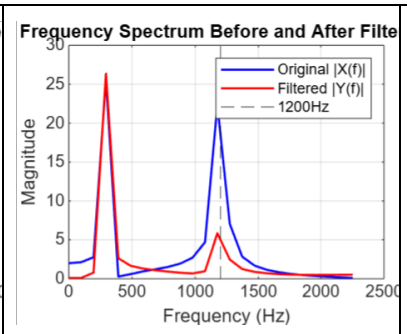
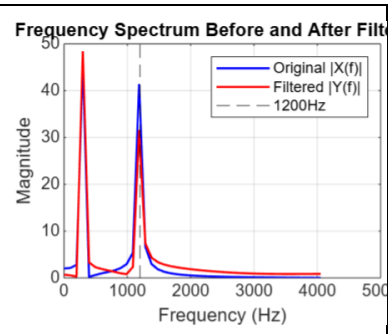
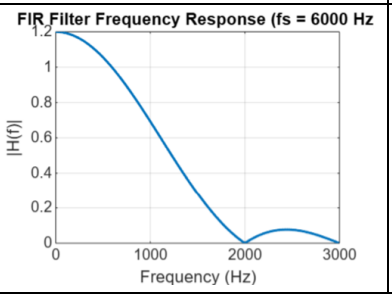
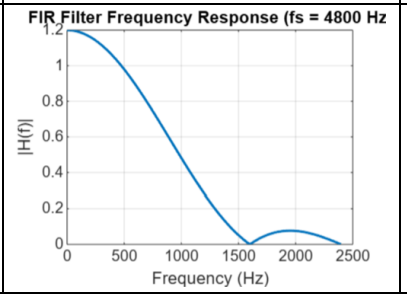
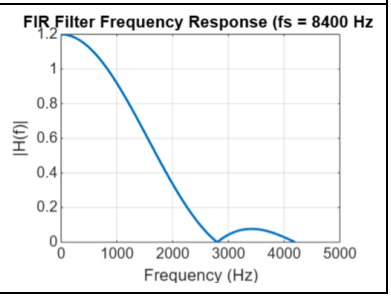
	
positive + negative	positive

peak	cutoff frequency (radians/sample)	normalized cutoff frequency (cycles/sample)	cutoff frequency for fs = 4000 Hz	cutoff frequency for fs = 8000 Hz
1.2	0.8468	0.8468/2π = 0.1348	539.06 (Hz)	1078.12 (Hz)

Part II Apply FIR Filter

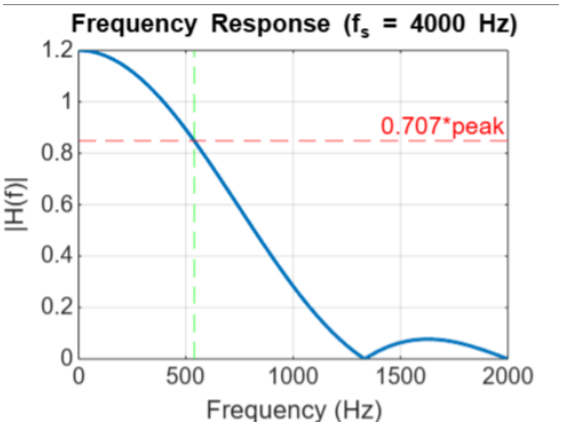
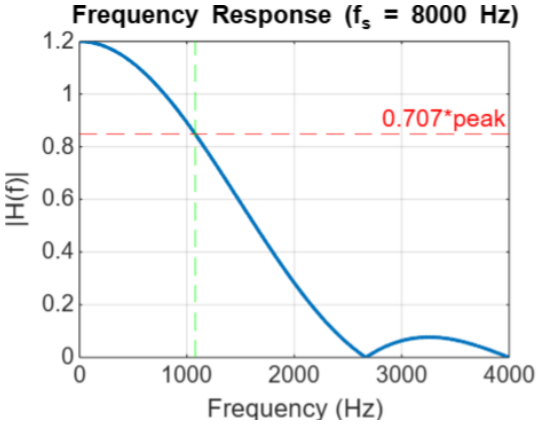
In Part II, I set the sampling frequency and create two discrete sinusoidal signals at 300Hz and 1200Hz to form the input signal. Then I filtered these three signals with a FIR filter and observed the filtering effect. I use stem to draw the discrete signals before and after filtering, fft to analyze the spectral changes, and finally freqz to draw the frequency response of the filter, which helps me to understand how the filter handles different frequency components.

Sampling Frequency	6000 (Hz)	4800 (Hz)	8400 (Hz)
Input Signal (without sampling)			
300Hz discrete signal			
1200Hz discrete signal			
Input Signal (with sampling)			

Frequency Domain			
Frequency Response			

According to the comparison graph above, the FIR filter successfully suppresses the 1200 Hz component while retaining the 300 Hz signal. As the fs increases, the cutoff frequency becomes higher, making it difficult to effectively filter out the 1200 Hz.

Part III The effect of Sampling Rate

fs = 4000 Hz	fs = 8000 Hz
fc = 539.06 Hz	fc = 1078.12 Hz
	

The cutoff frequency increases as the sampling rate increases, since the filter is designed based on normalized frequency. If the sampling rate is too high, the filter may no longer suppress the target frequency (e.g., 1200Hz). Therefore, the choice of fs significantly affects filtering performance.

C. Judgment

This project really helped me connect what we learned in class to real filtering results. Seeing how sampling rate changes the filter's behavior made the concepts easier to understand.

D. Conclusion

The sampling rate directly affects the actual cutoff frequency of an FIR filter, so choosing the right fs is essential for achieving the desired filtering results.