California State University, Northridge

Department of Electrical & Computer Engineering

ECE 351 - Linear Systems II

Summer 2023

Final Project

Digital Filter Design in MATLAB

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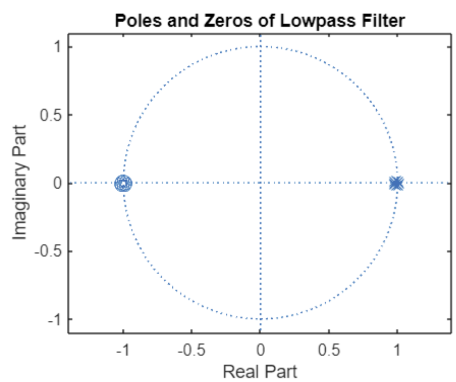
1. Introduction:

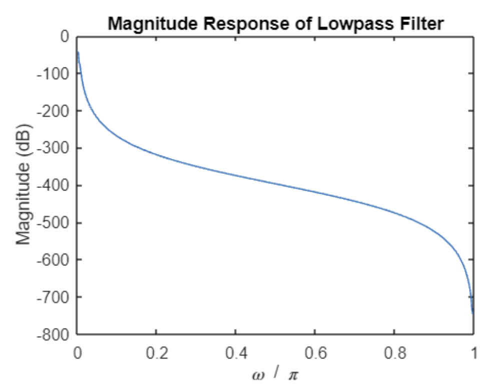
Final project for ECE 351 at CSUN Summer 2023. The purpose of this project is to familiarize us with the tools that allow us to build filters for digital discrete signals in MATLAB. This project allows us to see a real world use case for some of the topics we have been studying in ECE351. All my code for this project can be found in the link below.
https://github.com/Robles-C/Digital-Filter-Design

2. 8th Order Filter Design:

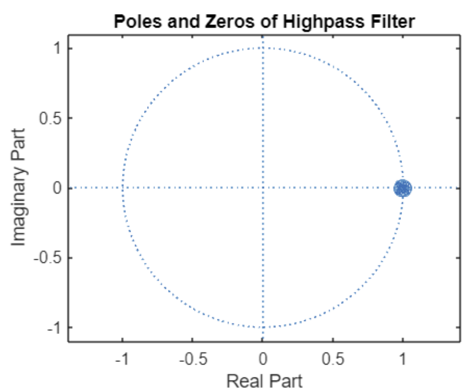
Instruction: For each of the following filters plot the poles and zeros in the complex z plane as well as the decibel magnitude response 20log_10(|H(e^Ω)|)

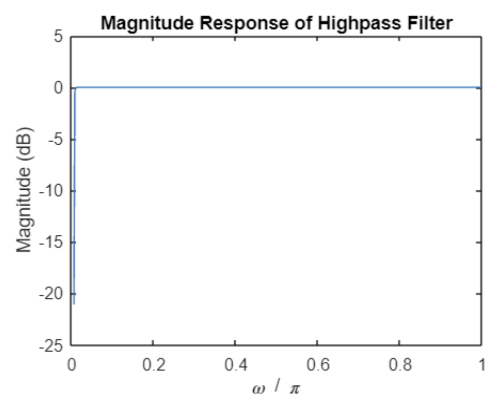
1. Low Pass Filter with Ωc = **π**/3



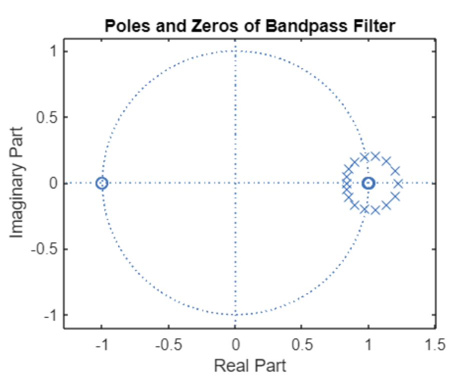


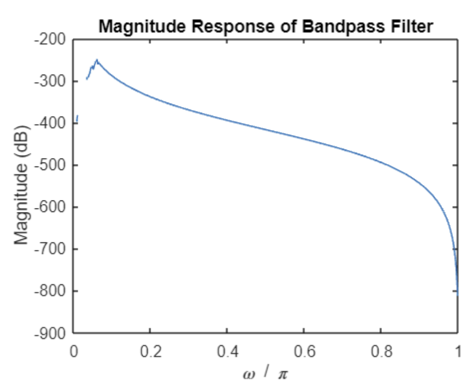
2. High Pass Filter with Ωc = **π**/3



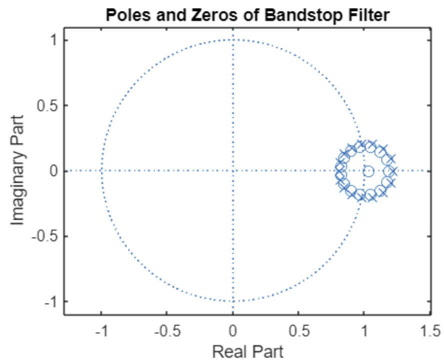


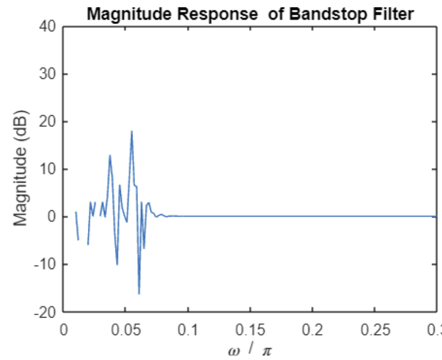
3. Band Pass Filter with passband between 5**π**/24 and 11**π**/24





4. Band Stop Filter with stopband between $5\pi/24$ and $11\pi/24$





3. Simulink Low Pass Filter:

Instruction: Develop a model in Simulink which models the lowpass filter in part (1.a) capable of filtering out high frequency noise signals from a noisy input measurement. Include all plots and developed models in Simulink in your report.

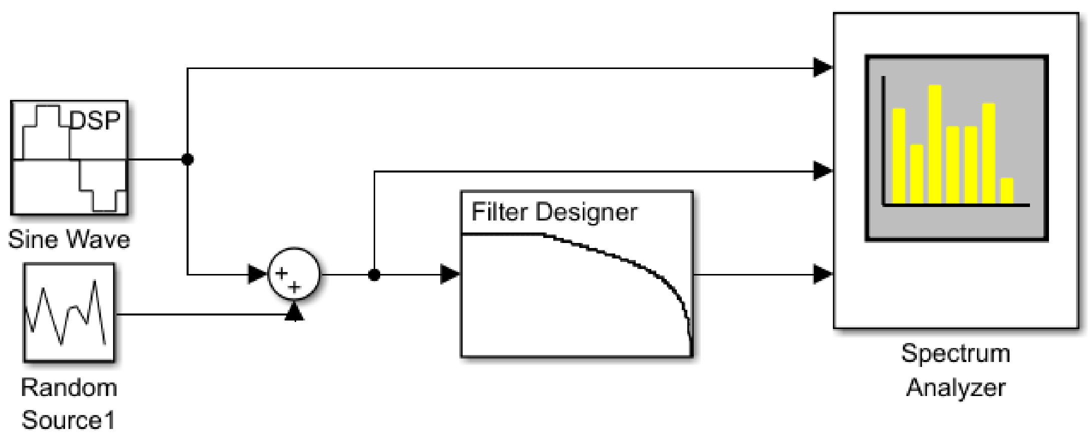


Figure 3.1 - Simulink Block Diagram

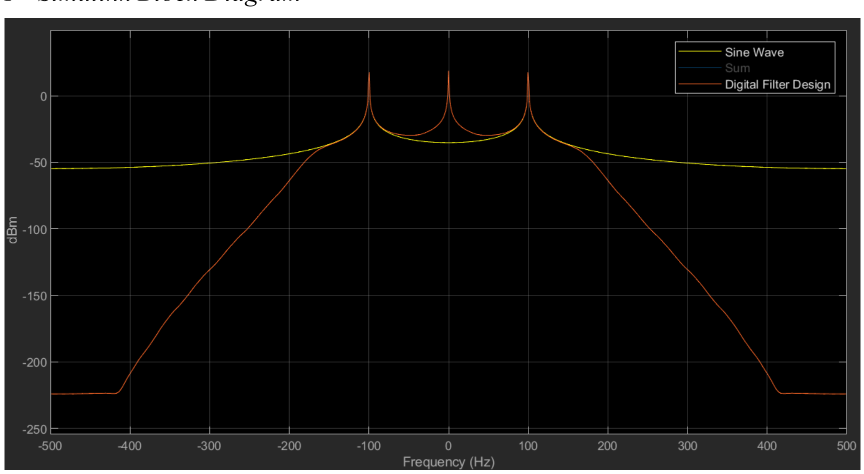


Figure 3.2 - Spectrum Analyzer Output of Sine Wave and Unfiltered Noisy Sine Wave

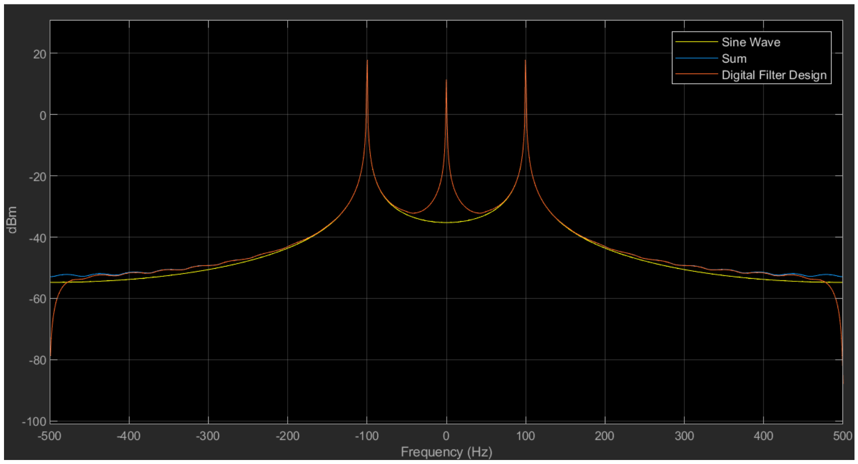


Figure 3.3 - Spectrum Analyzer Output of Sine Wave and High Frequency Noise Filtered Sine Wave

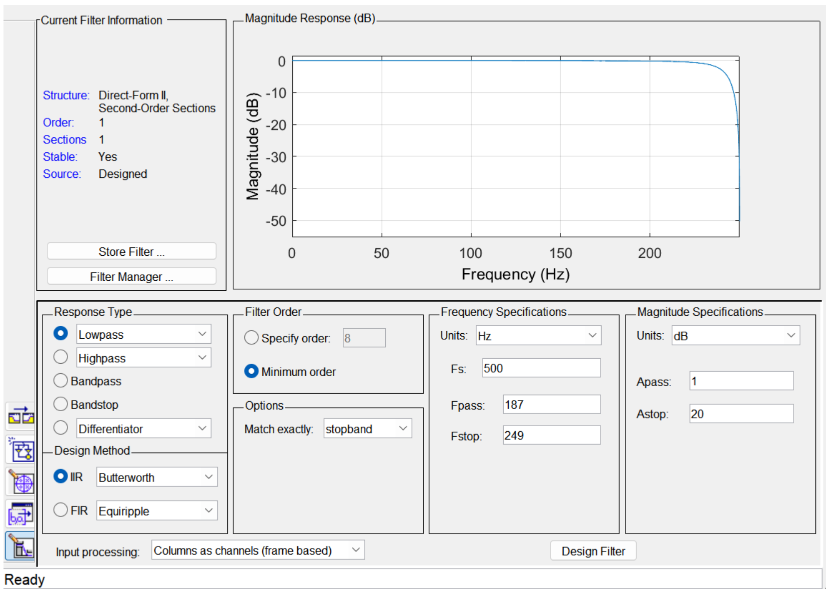


Figure 3.4 - Filter Designer Tool with Specifications for Low Pass Filter from Signal in Figure 3.3

4. Effects of Stop Band Ripple on Chebyshev Type II:

Instruction: A Chebyshev type II filter has smooth passband and ripple in the stopband. Setting the stopband ripple Rs=20 dB down, repeat the problem above using the cheby2 command. With all other parameters held constant, what is the general effect of increasing Rs, the minimum stopband attenuation?

```
% Parameters needed for cheb filter
Fs = 500;          % Sampling frequency
Fp = 100;           % Passband frequency
Fst = 150;          % Stopband frequency
Rp = 10;             % Passband ripple (dB)
Rs = 30;
[N, Wn] = cheb2ord(Fp/(Fs/2), Fst/(Fs/2), Rp, Rs);
[b, a] = cheby2(N, Rs, Wn, 'low');
```

Figure 4.1 - Commands used for Chebyshev II filter design with constant Fs, Fp, Fst, Rp Parameters

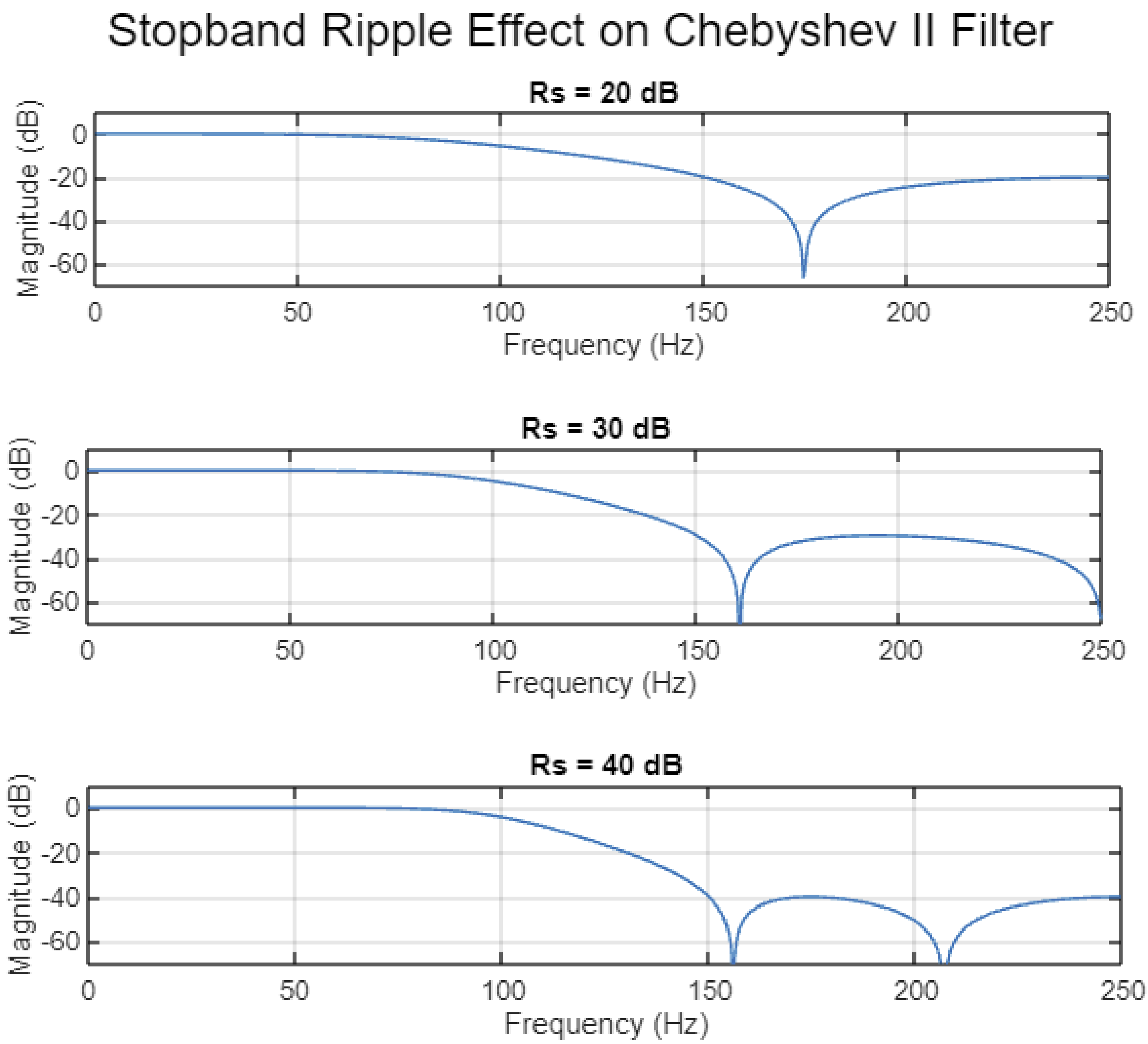


Figure 4.2 - Magnitude Response of Chebyshev II Filter with different Ripple Stop Band Values (Rs = 20, 30, 40)

The effect of increasing the Rs value on the Chebyshev II filter is that it reduces the minimum stopband attenuation. When Rs value was at 20 dB the minimum stopband attenuation was near 175 hertz. With all parameters constant and an increase in Rs the minimum stopband attenuation was at a lower frequency.

5. Sources:

Links of sources used to help me accomplish my project

- *Cutoff Freq of butterworth filter*. MATLAB Answers - MATLAB Central. (n.d.). https://www.mathworks.com/matlabcentral/answers/54875-cutoff-freq-of-butterworth-filter

- Frequency response - MATLAB & simulink. (n.d.). https://www.mathworks.com/help/signal/ug/frequency-response.html
- *Y*. Convert magnitude to decibels - MATLAB. (n.d.). https://www.mathworks.com/help/signal/ref/mag2db.html
- *N*. Chebyshev Type II filter design - MATLAB. (n.d.). https://www.mathworks.com/help/signal/ref/cheby2.html