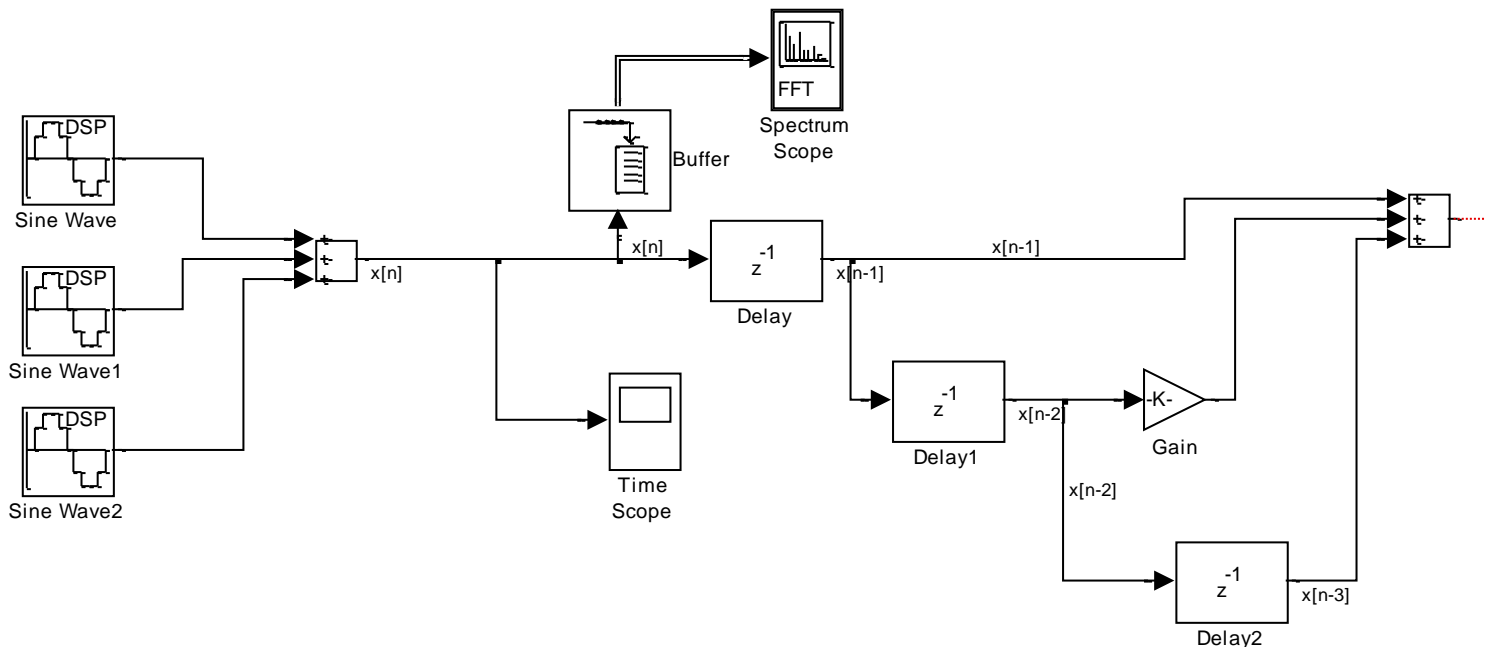


1. A causal LTI filter is characterized by the following CCLDE:

$$y[n] = x[n - 1] - 1.2x[n - 2] + x[n - 3] + 1.3y[n - 1] - 1.04y[n - 2] + 0.222y[n - 3]$$

- a. Determine  $H(z)$  corresponding to this filter, as well as the ROC.
- b. Express  $H(z)$  in factored form. To do this you need to obtain poles and zeros. Use Matlab to obtain zeros and poles.
- c. Obtain the pole – zero plot
- d. Using the freqz command in Matlab, obtain the DTFT of  $h[n]$ . Plot the magnitude and phase spectra of this system. Compare the magnitude response to the zero-pole plot, and interpret. What kind of a filter is this? What frequency or frequencies does it filter?
- e. Design this filter so that it has a sharper characteristic at the cutoff frequency. What would you do?
- f. Does this system have linear – phase. Why or why not?
- g. Design a test signal, that includes the frequency to be filtered out, as well as frequencies that are nearby. Filter this signal with the original filter given above, and the one you created. Compare the results.
- h. Design a Simulink model of the above system and test with a signal similar to that in (g). The first half of the design is given below to get you started.

Provide appropriate plots for each question to justify and / or clarify your answer, where appropriate.



2. Use the **sptool** command in Matlab to familiarize yourself with Matlab's signal processing GUI functions. Using this tool and the zero-pole based design, design the following. For each, provide pole-zero plots, impulse response and frequency response. Also, create test signals for each and show that they filter out the expected frequency. Use a sampling rate of 1000 Hz, for all test signals.
- a lowpass filter that blocks all frequencies above 120 Hz. Show at least three different designs, where the transition frequency is increasingly sharper. What is the cost of this sharpness?
  - a highpass filters that block all frequencies below 120 Hz. Compare this design to the previous. How are the impulse responses of these two types of filter related? Can you generalize? Come up with a simple transformation to go from lowpass to highpass.
  - Design a bandpass filter that passes the frequencies 50 to 100 Hz.
  - Design a bandstop that blocks 50 to 100 Hz.
  - Design a notch filter that blocks 60 Hz.