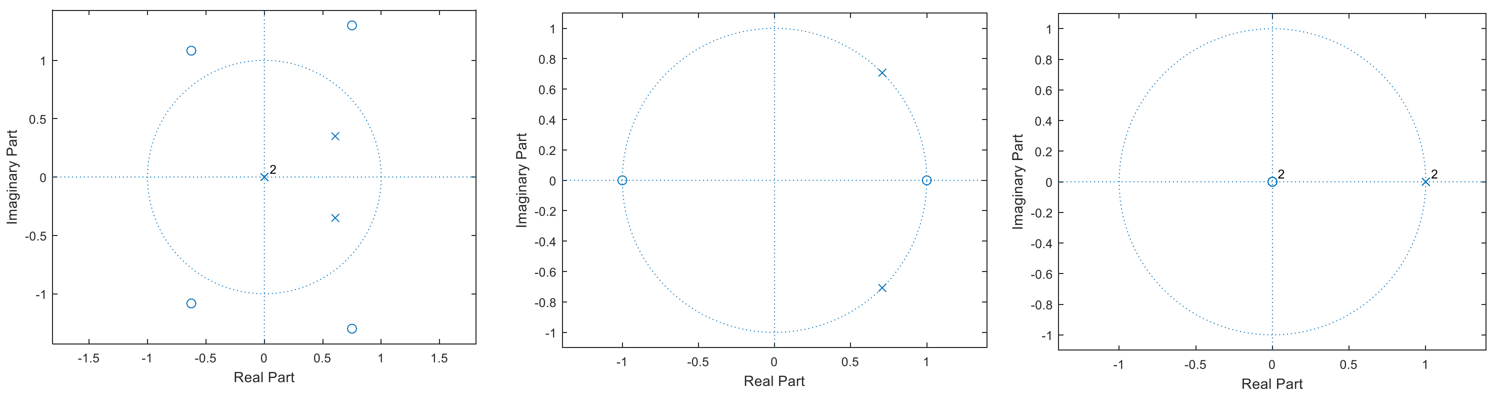
ECE 4429a – Advanced Digital Signal Processing
Fall 2020
Pole-zero based filtering
November 11, 2020

NOTES:

1. Lab reports must be submitted individually. **<u>Due Date: November 18, 2020, 6:30 pm. No email submissions, only OWL Dropbox submissions allowed.</u>**
2. Create a folder labeled "Lab3" on your Drop Box space in the course OWL site and upload your report and associated code to that directory.
3. Create a Word document that contains MATLAB figures, results, and your comments for each problem. Upload this document to the Lab3 folder.
4. Make sure you clearly label the axes for all MATLAB figures. Failing to do so may result in penalties!

Transfer function synthesis and stability (4 marks)



1. Synthesize the transfer function of DT systems whose pole-zero plots are shown above, using the *zp2tf* function. For the first pole-zero plot, the zeros are at $1.4e^{\pm j\pi/3}$ and $1.2e^{\pm j2\pi/3}$ and the non-zero pole pair at $0.7e^{\pm j\pi/6}$. For the second pole-zero plot, the poles are at angle of $\pm\frac{\pi}{4}$. Include the transfer functions in your report.
2. Compute the impulse response from each transfer function from (1) using the *impz* function. Include a plot of the impulse response in your report.
3. Comment on the stability of each system based on the impulse response.

Pole-zero, magnitude, and phase response plots (8 marks)

The transfer function of a digital filter is given by:

$$H(z) = \frac{1}{1 + 0.1929z^{-1} + 0.9861z^{-2} - 0.2393z^{-3} + 0.4408z^{-4} - 0.1956z^{-5} + 0.1139z^{-6}}$$

1. Obtain the pole-zero plot for this filter and include it in your report. Based on the pole-zero plot, can you guess what type of filter it might be (in terms of its frequency response)?
2. Is this system stable? Explain your reasoning. Confirm your answer, by plotting the impulse response of this filter. Include this plot in your report, along with your comments.
3. Obtain the magnitude and phase response plots of this filter and include them in your report. Comment on the magnitude response. Does it look like what you expected?

Notch filter design & implementation (8 marks)

1. Download “ecgbn.dat” from “Resources -> Labs -> Lab3” directory on course OWL site, and load it into MATLAB. This file contains Electrocardiogram (ECG) data sampled at 600 Hz, with power line interference. Using spectrum analysis, identify the interference components.
2. Design a notch filter to remove the unwanted frequencies by following these steps: (a) determine the pole and zero locations, based on the identified interference components. You have to assume the pole radii and include rationale for your choice for the pole radii; and (b) build numerator and denominator polynomials for the transfer function. You can use the “zp2tf” function in MATLAB for this.
3. Using the information from step #2, obtain the pole-zero, magnitude, and phase response plots. Include these in your report, along with your observations.
4. Use the transfer function from step #2 to filter the recorded ECG signal. Using the subplot command, plot the original ECG recording on the top panel, and the filtered ECG recording on the bottom panel. What are the effects of the notch filtering on the ECG recording? Can you identify the transient response of the filter?