

FALL 24 EC516 Problem Set 05

Due: Sunday October 13 (Before 11:59pm)

You must submit your homework attempt on Blackboard Learn. For this purpose, you must convert your homework attempt to a pdf file and upload it at the corresponding homework assignment on Blackboard Learn.

Problem 4.1

Consider a *second order section* with the system function:

$$H(z) = \frac{1}{(1 - 0.9e^{j\frac{\pi}{4}}z^{-1})(1 - 0.9e^{-j\frac{\pi}{4}}z^{-1})}$$

- (a) Determine a difference equation relating the input and output of this second order section?
- (b) Is it true that if the input signal to this filter is real-valued, the output signal from this section is also guaranteed to be real? Explain your answer.
- (c) Draw a Direct Form II flowgraph for this second order section and specify the number of multiplications per output sample by stored coefficients and the number memory retrievals per output sample for this implementation. Are the stored coefficients all real valued? Are the intermediate signals in the flowgraph also guaranteed to be real as long as the input signal to the second order section is real? Explain your answers.
- (d) Sketch the pole-zero plot for the system function for this second order section.
- (e) Draw by hand an approximation to the magnitude of the frequency response of this second order section. Is the magnitude of the frequency response zero at any frequency?

Problem 4.2

Consider a *second order section* with the system function:

$$H(z) = \frac{(1 + z^{-2})}{(1 - 0.9e^{j\frac{\pi}{4}}z^{-1})(1 - 0.9e^{-j\frac{\pi}{4}}z^{-1})}$$

- (a) Determine a difference equation relating the input and output of this second order section.
- (b) Is it true that if the input signal to this filter is real-valued, the output signal from this section is also guaranteed to be real? Explain your answer.
- (c) Draw a Direct Form II flowgraph for this second order section and specify the number of multiplications per output sample by stored coefficients and the number memory retrievals per output sample for this implementation. Are the stored coefficients all real valued? Are the intermediate signals in the flowgraph also guaranteed to be real as long as the input signal to the second order section is real? Explain your answers.

- (d) Sketch the pole-zero plot for the system function for this second order section.
- (e) Draw by hand an approximation to the magnitude of the frequency response of this second order section. Is the magnitude of the frequency response zero at any frequency?

Problem 4.3

Consider a causal filter **F** with the system function:

$$H(z) = (1 - z^{-8})$$

- (a) Is the filter **G** FIR or IIR? Justify your answer.
- (b) Draw a flowgraph for the filter **F** as a cascade of second order sections (each implemented as a Direct Form II flowgraph), making sure that the stored coefficients of each of the second order sections are all real-valued.
- (c) Sketch the pole-zero plot for the system function of **F** and indicate its region of convergence.
- (d) Sketch by hand an approximation to the magnitude of the frequency response of filter **F**

Problem 4.4

Consider a causal filter **G** with the system function, $H(z)$, such that (1) $H(z)$ has a total of five zeros, one each at -1 , $e^{j5\pi/6}$, $e^{-j5\pi/6}$, $e^{j2\pi/3}$, and $e^{-j2\pi/3}$ and (2) $H(z)$ has a total of five poles, one each at 0.5 , $0.5e^{j\pi/6}$, $0.5e^{-j\pi/6}$, $0.5e^{j\pi/3}$, and $0.5e^{-j\pi/3}$. You are also given that $H(1) = 1.0$

- (a) Is the filter **G** FIR or IIR? Justify your answer.
- (b) Draw a flowgraph for the filter **G** as a cascade of second order sections (each implemented as a Direct Form II flowgraph), making sure that the stored coefficients of each of the second order sections are all real-valued.
- (c) Sketch the pole-zero plot for the system function of **G** and indicate its region of convergence.
- (d) Sketch by hand an approximation to the magnitude of the frequency response of filter **G**. Would you characterize this filter as an approximation to a *lowpass filter* or to a *highpass filter*? Justify your answer