EE 4015 Digital Signal Processing

Semester A 2022-2023

Assignment 2

"It is not that I'm so smart. But I stay with the questions much longer." ~ Albert Einstein

Due Date: 11:00PM, Nov. 1, 2022 (Week 10)

1. A stable discrete-time system with input $x[n]$ and output $y[n]$ is described by the following difference equation:

$$y[n] = 0.1y[n-1] + 0.12y[n-2] + 7x[n]$$

(a) Determine the transfer function $H(z)$ of this system. [3 marks]

(b) Find all pole and zero locations of $H(z)$. [3 marks]

(c) Determine the impulse response $h[n]$ of the system. [3 marks]

(d) Compute the magnitude and phase responses of $H(e^{j\omega})$ which is the discrete-time Fourier transform (DTFT) of $h[n]$. [6 marks]

2. Figure 1 shows the block diagram representation of a causal linear time-invariant system with input $x[n]$ and output $y[n]$. Note that a is a real number.

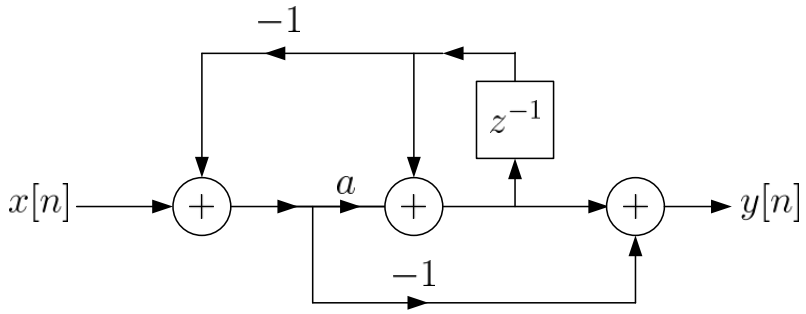

Figure 1

(a) Determine the system transfer function $H(z)$. [12 marks]

(b) Determine the system impulse response $h[n]$. [4 marks]

(c) For what range of values of a is the system stable? [4 marks]

3. Consider a causal LTI system whose system function is

$$H(z) = \frac{1 - \frac{1}{5}z^{-1}}{\left(1 - \frac{1}{2}z^{-1} + \frac{1}{3}z^{-2}\right)\left(1 + \frac{1}{4}z^{-1}\right)}$$

Draw the signal flow graphs for the system in each of the following forms:

(a) Direct form

(b) Canonic form

(c) Cascade form using canonic form sections

(d) Parallel form using canonic form sections

[20 marks]

4. The impulse response of an LTI system is:

$$h[n] = \delta[n] - \delta[n-1]$$

Let the system input and output be $x[n]$ and $y[n]$, respectively.

(a) Does $h[n]$ correspond to a linear phase discrete-time system? Explain your answer. [5 marks]

(b) Determine $H[k]$, which is the Discrete Fourier Transform (DFT) of $h[n]$. [6 marks]

(c) Determine the system transfer function $H(z)$. Then find all pole and zero locations of $H(z)$. [6 marks]

(d) Compute the system frequency response $H(e^{j\omega})$. Then determine its magnitude and phase responses, that is, $|H(e^{j\omega})|$ and $\angle H(e^{j\omega})$. [12 marks]

(e) Compute the maximum and minimum values of $|H(e^{j\omega})|$. The system should be one of the following: lowpass, highpass, bandpass or bandstop filter. Which of them? [10 marks]

(f) Compute $y[n]$ when $x[n] = \cos(\pi n/2)$ for all n. [6 marks]