ICE503 DSP-Homework#10

1. Suppose we have two four-point sequences $x[n]$ and $h[n]$ as follow:

$$x[n] = \sin\left(\frac{\pi n}{2}\right), n = 0,1,2,3$$

$$h[n] = 2^n, \qquad n = 0,1,2,3$$

(a) Calculate the four-point DFT $X[k]$.

(b) Calculate the four-point DFT $H[k]$.

(c) Calculate $y[n] = x[n]$ 4 $h[n]$ by doing the circular convolution directly.

(d) Calculate $y[n]$ of Part (c) by multiplying the DFTs of $x[n]$ and $h[n]$ and performing an inverse DFT.

ICE503 DSP-Homework#10

1. The convolution of discrete-time system with an impulse response $h[n]$ is given by:

$$\mathrm{y[n]} = \sum_{k=-\infty}^{\infty} h[k]x[n-k],$$

derive the z-transforms of transfer function $\mathrm{Y(z)} = \mathrm{H(z)X(z)}$ step by step.

2. A causal linear time-invariant system has the system function

$$H(z) = \frac{(1 - 1.5z^{-1} - z^{-2})(1 + 0.9z^{-1})}{(1 - z^{-1})(1 + 0.7jz^{-1})(1 - 0.7jz^{-1})}$$

(a) Write the difference equation that characterizes the system with $x[n]$ and $y[n]$.

(b) Plot the pole-zero diagram and indicate the region of convergence for the system function.

ICE503 DSP-Homework#12

1. Figure 1 shows the impulse response for several different LTI systems. Determine the group delay associated with each systems.

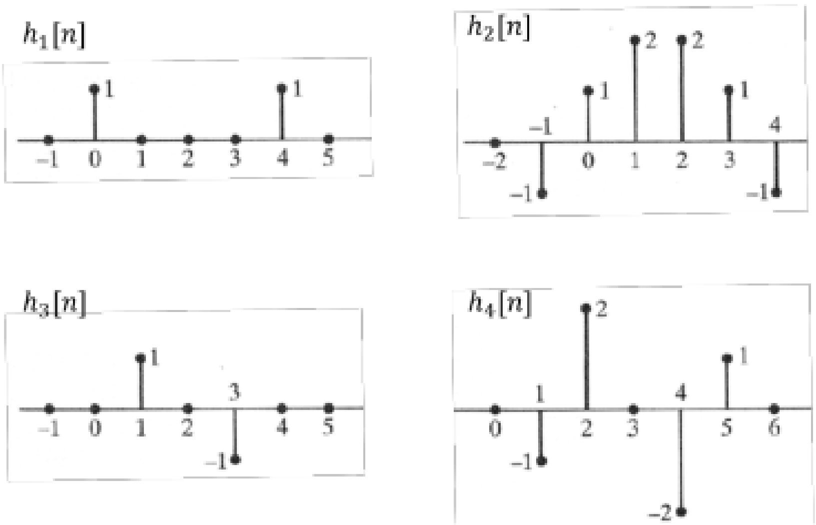

Figure 1: Impulse response for several different LTI systems

2. Figure 2 shows two different interconnections of three systems. The impulse responses $h_1[n]$, $h_2[n]$, and $h_3[n]$ are as shown in Figure 3. Determine whether system A and/or system B is a generalized linear-phase system.

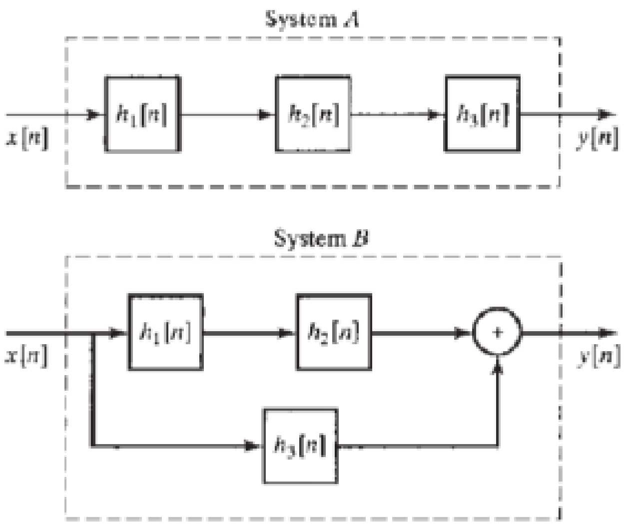

Figure 2: Two different interconnections of three systems

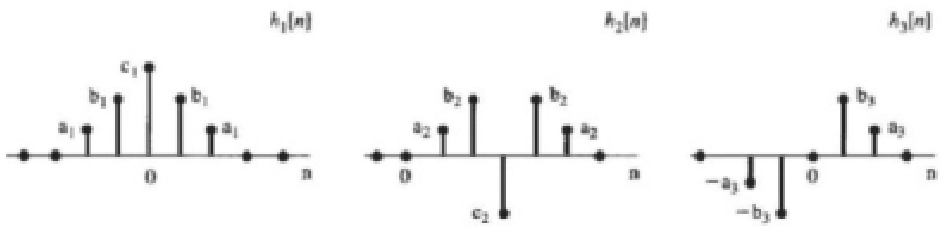

Figure 3 Impulse responses of the three systems

ICE503/IMPTE502 – Final Examination

1. (a) (30%) Plot the flow graph of an 16-point decimation-in-time FFT structure. **Please provide details of your development.**

   (b) (10%) Determine the number of complex multiplications.

2. (25%) A causal time-invariant system has the system function

$$H(z) = \frac{(1+0.9z^{-1})(1-1.5z^{-1}-z^{-2})}{(1-0.8z^{-1})(1+0.5jz^{-1})(1-0.5jz^{-1})}$$

a) (5%) Write the difference equation that is satisfied by the input and output of the system.

b) (5%) Plot the pole-zero diagram and indicate the region of convergence for the system.

c) (5%) Sketch $|H(e^{j\omega})|$.

d) (5%) Draw the signal flow graphs for implementations of the system using cascading form with first- and second-order sections of transposed Direct Form II.

e) (5%) Represent $H(z)$ as a cascade of a minimum-phase system $H_{\min}(z)$ and a unity-gain all-pass system $H_{\text{ap}}(z)$.

3. (20%) The impulse response of $h[n]$ is as shown in Figure 1.

a) (10%) Is $h[n]$ a generalized linear-phase system? If your answer is yes, determine which type $h[n]$ belong to? If your answer is no, explain why?

b) (10%) Is $h[n] * h[n]$ (i.e., cascade of two $h[n]$) a generalized linear-phase system? If your answer is yes, determine which type $h[n]$ belong to? If your answer is no, explain why?

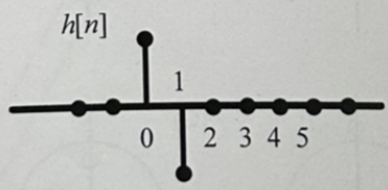

Figure 1: Impulse response of $h[n]$.

4. (15%) Design of FIR filters by windowing, given $M = 7$, sample rate 1 Hz

$$h_t[n] = h_d[n] \cdot w_R[n],$$

$$w_R[n] = \begin{cases} 1, & -M \leq n \leq M, \\ 0, & \text{otherwise.} \end{cases}$$

a) (5%) Calculate $W_R(e^{j\omega})$.

b) (5%) Plot $|W_R(e^{j\omega})|$, and indicate the magnitude of the mainlobe.

b) (5%) If $h_d[n]$ represents an ideal low-pass filter, sketch the magnitude response $|H_t(e^{j\omega})|$ and indicate the transition width from the frequency point of the peak in the passband to the peak in the stopband.

5. (20%) Figure 2 shows the pole-zero plots for eight different system functions.

(a) What systems are IIR systems?

(b) What systems are stable systems?

(c) What systems are minimum-phase systems?

(d) What systems are generalized linear-phase systems?

(e) What systems have the same magnitude response?

(f) What systems have $|H(e^{j\omega})| = $ constant for all ω?

(g) What systems have corresponding stable and causal inverse systems?

(h) What system has the shortest (latest number of nonzero samples) impulse response?

(i) What systems have lowpass frequency responses?

(j) What systems are FIR Type III linear-phase systems?

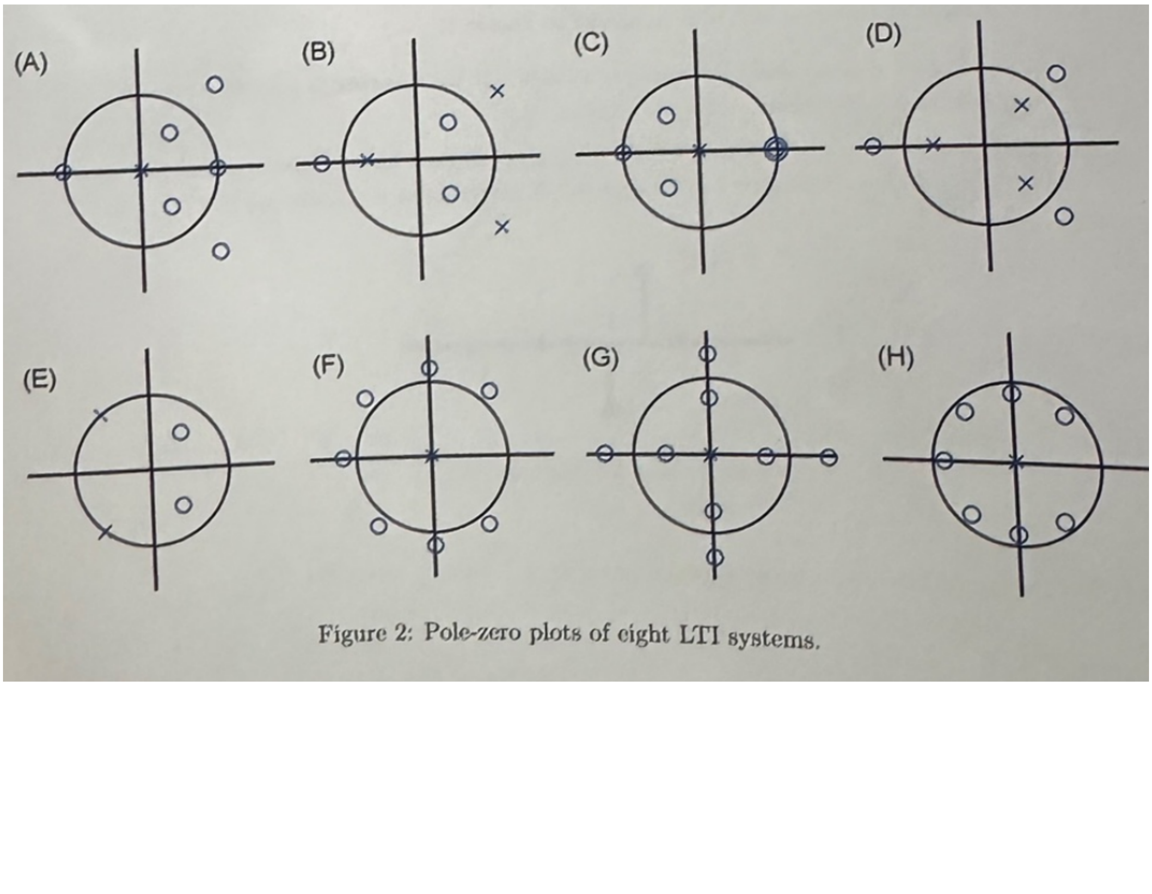

Figure 2: Pole-zero plots of eight LTI systems.