

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?

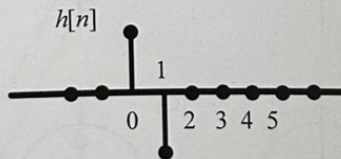


Figure 1: Impulse response of $h[n]$.

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.

- What systems are IIR systems?
- What systems are stable systems?
- What systems are minimum-phase systems?
- What systems are generalized linear-phase systems?
- What systems have the same magnitude response?
- What systems have $|H(e^{j\omega})| = \text{constant}$ for all ω ?
- What systems have corresponding stable and causal inverse systems?
- What system has the shortest (latest number of nonzero samples) impulse response?
- What systems have lowpass frequency responses?
- What systems are FIR Type III linear-phase systems?

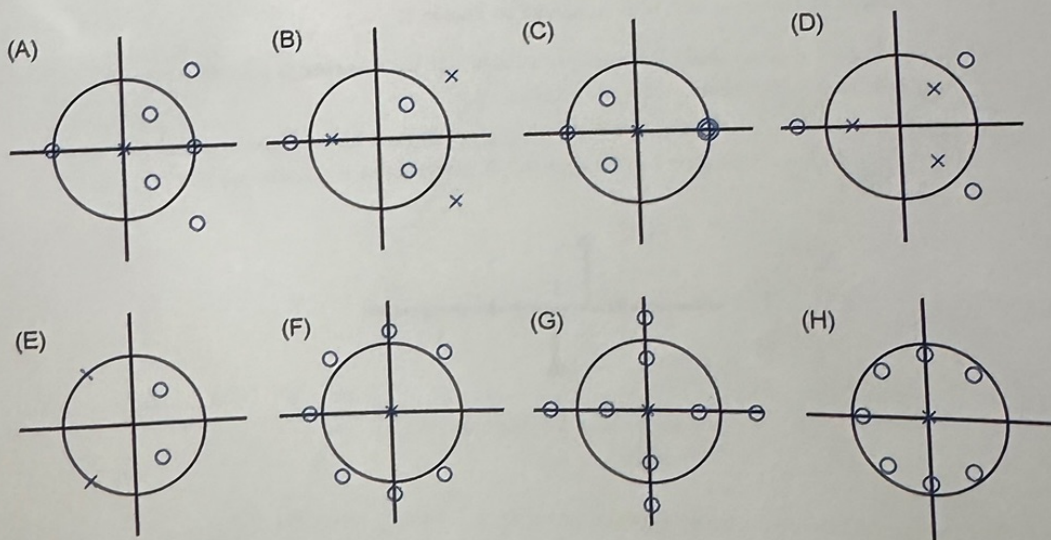


Figure 2: Pole-zero plots of eight LTI systems.