GLASGOW COLLEGE UESTC

Exam paper

Digital Signal Processing (UESTC 4005)

Date: 2^{nd} , September,2020
Time:16:30—18:30

Attempt all PARTS. Total 100 marks

Make sure that your University of Glasgow and UESTC Student Identification Numbers are on all answer sheets.

An electronic calculator may be used provided that it does not allow text storage or display, or graphical display.

DATA/FORMULAE SHEET IS PROVIDED AT THE END OF PAPER

Table 10.2 Properties of some fixed window functions

Type of windows	Main lobe width Δ_{ML}	Relative sidelobe level A_{sl}	Minimum stopband attenuation α_s	Transition bandwidth Δ_ω
Rectangular	$4\pi/(2M+1)$	13.3dB	20.9dB	$0.92\pi/M$
Hann	$8\pi/(2M+1)$	31.5dB	43.9dB	$3.11\pi/M$
Hamming	$8\pi/(2M+1)$	42.7dB	54.5dB	$3.32\pi/M$
Blackman	$12\pi/(2M+1)$	58.1dB	75.3dB	$5.56\pi/M$

Continued overleaf

Q1 The zero-pole plots in Figure Q1 describe six different causal LTI systems.

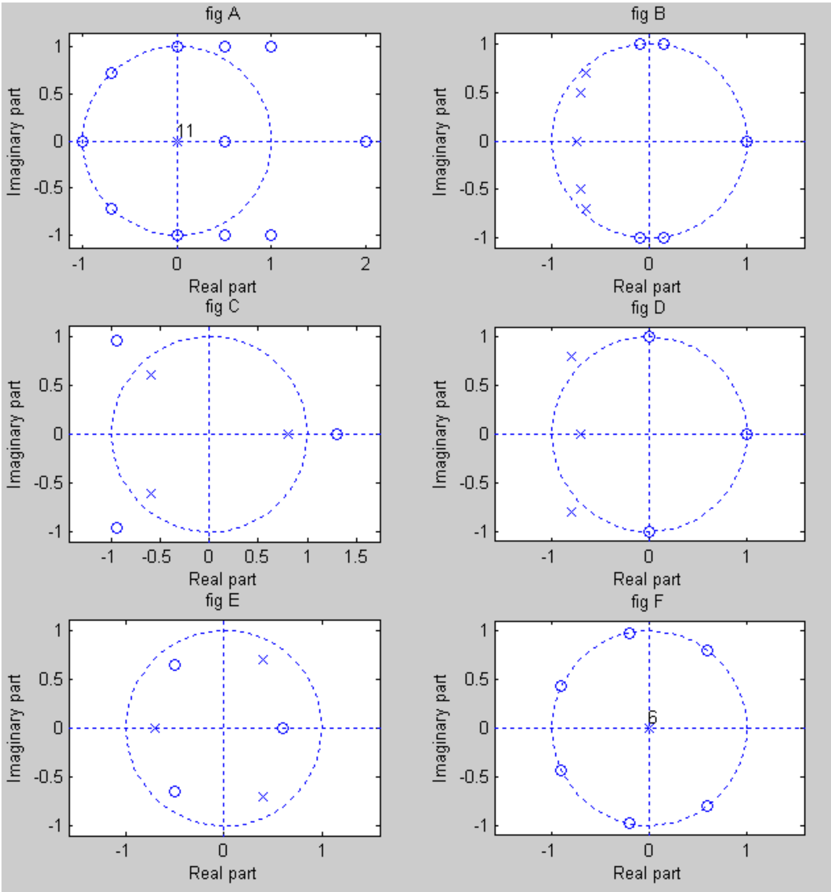

Figure Q1 zero-pole plots of six different causal LTI systems

Answer the following questions about systems with the above pole-zero plots. In each case, an acceptable answer could be none or all.

1. Which systems are IIR system? Why? [5]
2. Which systems are stable system? Why? [5]
3. Which systems are minimum-phase system? Why? [5]
4. Which systems are linear-phase system? Why? [5]
5. Which systems have $|H(e^{j\omega})|$=constant for all ω? Why? [5]

Continued overleaf

Q2 Suppose $x_a(t) = \sin(2\pi \times 1000t)$ being a real causal sinusoidal analog signal.

1． If the sampling frequency is 8000Hz, please determine the expression of the sampled signal x[n]. [6]

2． What is the digital angular frequency of the sampled signal x[n]? [5]

3． Calculate the DTFT $X(e^{j\omega})$ and 256-point DFT $X[k]$ of x[n], where $0 \le n \le 255$. [8]

4． Please point out the peaks of the magnitude of DTFT and DFT respectively. What are the corresponding original analog frequencies of them. [6]

Q3 The impulse response of an linear time-invariant system is

$$h[n] = \begin{cases} a^n, 0 \le n \le 7 \\ 0, otherwise \end{cases}$$

(a) Determine the transfer function H(z). [5]

(b) Draw the flow graph of a direct form implementation of the system. [5]

(c) Draw the flow graph of an implementation of H(z), as expressed in part(b), corresponding to a cascade of an FIR system (numerator) with an IIR system (denominator). [5]

(d) Which implementation of the system above requires

(i) the more storage (delay elements)? [5]

(ii) the more arithmetic (multiplications and additions per out sample)? [5]

Q4 Suppose we want to design a linear phase FIR low-pass filter to process analog signal. If specifications of the filter in analog form are given as: the passband edge frequency f_p=1000Hz，the passband ripple is 1dB, the stopband edge frequency f_s=1500Hz, the minimum stopband attenuation<-40dB, the sampling frequency f_T=10000Hz.Try to:

(i) Design the FIR filter with the least order based on windowed Fourier series with fixed windows given in table10.2. （Hint：design based on the FIR design steps） [10]

(ii) Based on (i),Give the impulse response of the filter. [5]

(iii) Select a kind of suitable linear phase realization. [5]

(iv) Plot a canonic direct realization of the system. [5]

End of question paper