UOG-UESTC Joint School of

University of Electronic Science and Technology of China

Digital Signal Processing — Spring 2018

Final Exam

10:00-12:00, 4th July, 2018

<u>Notice:</u> Please make sure that both your UESTC and UoG Student IDs are written on the top of every sheet. This examination is open-book and the use of electronic materials or a cell phone is not permitted. All scratch paper must be adequately labeled. Unless indicated otherwise, answers must be derived or explained clearly. Please write within the space given below on the answer sheets.

All questions are compulsory. There are 6 questions and a maximum of 100 marks in total.

The following table is for grader only:

Question	1	2	3	4	5	6	Total	Grader
Score								

Score

Question1 (20 points, 5 points for each subproblem)

Please sketch the waveform of the following discrete sequences

(1) $f_1[k] = u[-k] - u[-k+1]$

(2) $f_2[k] = \sum_{p=0}^{\infty} \delta[k-p]$

(3) $f_3[k] = \sin(\pi k/2) - \sin[\pi(k-1)/2]$

(4) $f_4[k] = \{0.5, 1.5, \underset{\uparrow}{2}, -2, 0, 1\}$

Score

Question2 (20 points)

(1) The following continuous signal

$$x_a(t) = 4\sin(20\pi t) - 5\cos(24\pi t) + 3\sin(120\pi t) + 2\cos(176\pi t)$$

is sampled with the frequency of F_s = 50Hz, thus yielding the discrete sequence $x[n]$. Please give the expressions of $x[n]$ and its DTFT, i.e., $X(e^{j\omega})$. (10 points)

(2) Please give the result of the following expression. (10 points)

$$\sum_{n=-\infty}^{\infty} \frac{\sin(\pi n/4)\sin(\pi n/6)}{10\pi^2 n^2}$$

Score

Question3 (15 points)

Given the following z-transform pair

$$h[n] = A_1\alpha_1^n u[n] + A_2\alpha_2^n u[n] \quad \xleftrightarrow{\text{ZT}} \quad H(z) = \frac{1}{1-0.25z^{-2}}.$$

Please determine the values of A_1, A_2, α_1 and α_2.

Score

Question4 (15 points)

Figure 1 displays the waveform of $H(e^{j\omega})$, which is the DTFT of the discrete sequence h[n].

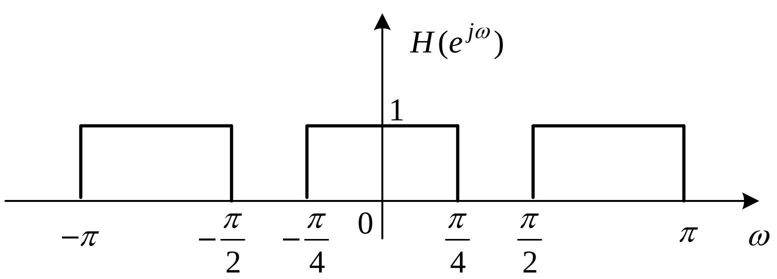

Figure 1

(1) Determine the expression of h[n];

(2) Construct 3 sequences, i.e., $h_1[n]$, $h_2[n]$, and $h_3[n]$, as follows

$$h_1[n] = (-j)^n h[n], \qquad h_2[n] = (j)^n h[n], \qquad h_3[n] = [(1+j)/\sqrt{2}]^n h[n]$$

Please sketch the DTFTs of them.

(3) Let h[n] be the impulse response of a discrete LTI system. Assume that the input signal is

$$x[n] = \frac{\sin(0.5\pi n)}{\pi n}$$

Please determine the output signal, which is denoted as y[n].

Score

Question5 (15 points)

The difference equation of a discrete-time LTI system is given as

$$y[n]-0.4y[n-1]-0.45y[n-2]=x[n-1]-0.2x[n-2]$$

(1) Determine the transfer function H(z) of the system;

(2) Sketch the flow graph of the direct form-II IIR implementation of the system;

(3) How many delay elements and arithmetic elements are required for the above implementation?

Score

Question6 (15 points)

Please design a causal bandpass FIR digital filter using windowing method, with the following specifications:

center frequency	**4kHz**
passband edges	**2.5 kHz and 5.5 kHz**
stopband edges	**0.5 kHz and 7.5 kHz**
stopband attenuation	**40 dB (passband ripple can be ignored)**
sampling frequency	**20kHz**

Please give the expression of h[n] in your design.

Type of Window	Main lobe width	Relative sidelobe level	Minimum stopband attenuation	Transition bandwidth
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	$5.56\pi/M$

Hann: $w[n] = 0.5+0.5\cos[2\pi n/(2M+1)]$, $-M \le n \le M$

Hamming: $w[n] = 0.54+0.46\cos[2\pi n/(2M+1)]$, $- M \le n \le M$

Balckman: $w[n] = 0.42+0.5\cos[2\pi n/(2M+1)]+0.08\cos[4\pi n/(2M+1)]$, $- M \le n \le M$