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Examination Answer Books

12 Pages

Instructions to Candidates

1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
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1	Student Number	NEA20856038
2	Title of Examination Paper	Digital Signal Processing and Communications
3	Module Code	60665003
4	Date and Time of Examination	22/05/2024 2:00
5	Examination Venue	68860 Main Hall
6	Seat Number	H4
7	Number of Answer Books handed in	

Complete, fold and seal
(see note 2 below)

SURNAME: Neale

FORENAME(S): Matthew

List the numbers of the questions you have attempted	Office Use
Q1	19 ✓
Q2	13 ✓
Q3	25 ✓
Q4	10 ✓
Total	67/100 ✓

(Gweler yr ochr arall am y fersiwn Cymraeg)

67%

1. a.

$$y[n] = x[n] - 4$$

$$y_1[n] = x_1[n] - 4$$

$$y_2[n] = x_2[n] - 4$$

$$\text{Weighted Sum} = a y_1[n] + b y_2[n] = a x_1[n] - 4a + b x_2[n] - 4b$$

$$\text{Weighted Sum} = a x_1[n] - 4a + b x_2[n] - 4b$$

using output for system input.

$$y[n] = H\{a x_1[n] + b x_2[n]\} = a x_1[n] + b x_2[n] - 4$$

Since these equations are not equal this system is not linear.

b. Time-invariant

$$y[n] = 2x[n-3]$$

$$y[n-k] = 2x[n-k-3]$$

$$\text{For } y[k] = H\{x[n-k]\} = 2x[n-k-3]$$

Since these equations are equal this system is time invariant.

c. i) $y[n] = 4x[n-1] - 3x[n-2] + 2y[n-1]$

The above system is causal as it does not rely on future terms for x or y .

ii) $y[n] = 6x[n+2] - 7x[n] + y[n+1]$

The system above is not causal as it relies on future x and y , thus these are

$$x[n+2] \text{ and } y[n+1]$$

1. d. $y[n] = -0.3y[n-1] + 0.7x[n]$

$$y[n] = -\sum_{i=1}^N a_i y[n-i] + \sum_{j=0}^M b_j x[n-j]$$

$$y[n] = -a_1 y[n-1] - a_2 y[n-2] \dots a_N y[n-N] + b_0 x[n] + b_1 x[n-1] + b_2 x[n-2] \dots b_M x[n-M]$$

i) This system is a non-recursive difference equation

ii) $a_1 = 0.3$, $b_0 = 0.7$ $a_0 = ?$

iii) $x[n] = u[n] = 1$

For $y[n] = \text{initial conditions of } y[-1] = 0$

?

Q1d

1/7

2. a. $x(t) = 8 \sin(2\pi Ft) u(t)$

i) $F_s = 10,000 \text{ Hz}$ $T = \frac{1}{F}$ $F = \frac{1}{T}$

$x(n) = 8 \sin(2\pi 10,000)(100 \times 10^{-6}) u(n)$

$T_s = 100 \mu\text{s}$

or $100 \times 10^{-6} \text{ seconds}$

$x(n) = 8 \sin(6.28) u(n)$

$x(n) = -0.025$

$t = nT_s$??

Show workings

ii)

When $u(n) = 1$

$x(n) = -0.025 \times 0 u(n) = 0$

$x(n) = -0.025 \times 1 u(n) = -0.025$

$x(n) = -0.025 \times 2 u(n) = -0.05$

$x(n) = -0.025 \times 3 u(n) = -0.075$

b. $x(n] = 5\delta[n+4] - 3\delta[n+2] + 2\delta[n] - 4\delta[n-1] + 3\delta[n-3]$
 $-2\delta[n-5] + \delta\delta_m[n-6]$

c. i) $h[n] = [2 \ -1 \ 4]$ $x[n] = [1 \ 3 \ 0 \ 2]$

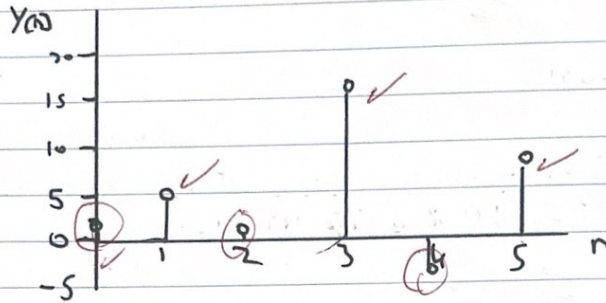
number of points = $3 + 4 - 1 = 6$

n	0	1	2	3	4	5
$h[n]$	2	-1	4			
$x[n]$	1	3	0	2		
$x[n]h[n]$	2	-1	4			
$x[n]h[n-1]$	delay	6	-3	12		
$x[n]h[n-2]$	delay	delay	0	0	0	
$x[n]h[n-3]$	delay	delay	delay	4	-2	8
$y[n]$	2	5	1	16	-2	8

$y[n] = [2 \ 5 \ 1 \ 16 \ -2 \ 8]$

ii)

$$y[n] = [2 \ 5 \ 1 \ 16 \ -2 \ 8]$$



show smaller tick marks

d. $x(t) = 4 \cos(6000\pi t) + 2 \cos(16,000\pi t) - 2 \cos(8000\pi t)$

Q2d

Nyquist Sampling Frequency or NSF

1/4

$$NSF = 2 \times \text{Frequency max} \quad \checkmark \quad \perp$$

$$\text{So here } NSF = 2 \times 16,000 = 32,000 \text{ Hz}$$

$$NSF = 32,000 \text{ Hz} \quad \times$$

Frequency components of $x(t)$ are

$$\begin{aligned} &6000\pi t \\ &16,000\pi t \\ &8,000\pi t \end{aligned}$$

 $\times$

3. a $x[n] = 3^n \cos(0.25\pi n) u[n]$

$$x[n] = a^n \cos(bn) u[n] \Rightarrow X(z) = \frac{z[2 - a \cos(b)]}{z^2 - [2a \cos(b)]z + a^2}$$

$a = 3, b = 0.25\pi$

So $X(z) = \frac{z[2 - 3 \cos(0.25\pi)]}{z^2 - 2(3) \cos(0.25\pi)z + 3^2}$

$X(z) = \frac{z[2 - 2.12]}{z^2 - 6 \cos(0.25\pi)z + 9}$

$X(z) = \frac{z^2 - 2.12z}{z^2 - 4.24z + 9}$

b. Find $H(z)$ of the system.

$$3y[n] - 2y[n-1] + y[n-2] = x[n] + 0.5x[n-1] - x[n-2] = 0$$

$$3y[n] - 2y[n-1] + y[n-2] = x[n] + 0.5x[n-1] - x[n-2]$$

$Y(z)$ Now $1[n] + 0 Y(z)$

$$3Y(z) - 2z^{-1}Y(z) + z^{-2}Y(z) = X(z) + 0.5z^{-1}X(z) - z^{-2}X(z)$$

$$Y(z)(3 - 2z^{-1} + z^{-2}) = X(z)(1 - 0.5z^{-1} + z^{-2})$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1 - 0.5z^{-1} + z^{-2}}{3 - 2z^{-1} + z^{-2}}$$

Q3

25/25

Q3a

7/7

Q3b

8/8

C. Find The frequency response, $H e^{j\omega}$.

Q3C

$$y[n] = 0.5 y[n-1] - 0.25 y[n-2] - x[n] + 0.6 x[n-1] - 0.4 x[n-2]$$

10/10

$$y[n] + 0.5 y[n-1] - 0.25 y[n-2] = x[n] - 0.6 x[n-1] + 0.4 x[n-2]$$

$$Y(z) + 0.5 z^{-1} Y(z) - 0.25 z^{-2} Y(z) = X(z) - 0.6 z^{-1} X(z) + 0.4 z^{-2} X(z)$$

$$Y(z) (1 + 0.5 z^{-1} - 0.25 z^{-2}) = X(z) (1 - 0.6 z^{-1} + 0.4 z^{-2})$$

$$H_z = \frac{Y(z)}{X(z)} = \frac{1 - 0.6 z^{-1} + 0.4 z^{-2}}{1 + 0.5 z^{-1} - 0.25 z^{-2}}$$

$$H e^{j\omega} = \frac{Y e^{j\omega}}{X e^{j\omega}} = \frac{1 - 0.6 e^{-j\omega} + 0.4 e^{-2j\omega}}{1 + 0.5 e^{-j\omega} - 0.25 e^{-2j\omega}}$$

10

4.A 7-Tap bandpass FIR filter

Filter length = $2M+1$

$$L.F = 800 \text{ Hz}$$

$$H.F = 3,000 \text{ Hz}$$

$$F_s = 12,000 \text{ Hz}$$

$$\omega_L = \omega = 2\pi f$$

$$\omega_L = 2\pi \times \frac{800}{12,000} = 0.133\pi$$

$$\omega_H = 2\pi \times \frac{3,000}{12,000} = 0.5\pi$$

$$\text{band pass } H(k) = \frac{\omega_H - \omega_L}{\pi} \quad \text{when } k=0$$

$$\text{or } \frac{\sin \omega_H \times k}{k\pi} - \frac{\sin \omega_L \times k}{k\pi} \quad -M \leq k \leq M$$

$$H(0) = \frac{0.5\pi - 0.133\pi}{\pi} = 0.367$$

$$H(1) = \frac{\sin 0.5\pi \times 1}{1\pi} - \frac{\sin 0.133\pi \times 1}{1\pi} = 0.189$$

$$h(2) = \frac{\sin 0.5\pi \times 2}{2\pi} - \frac{\sin 0.133\pi \times 2}{2\pi} = -0.118$$

$$h(3) = \frac{\sin 0.5\pi \times 3}{3\pi} - \frac{\sin 0.133\pi \times 3}{3\pi} = -0.207$$

using Symmetry (Window Function)

$$h(-1) = h(1) = 0.189$$

$$h(-2) = h(2) = -0.118$$

$$h(-3) = h(3) = -0.207$$

$$b_k = h(k-m)$$

$$h(-3) = -0.207$$

$$h(-2) = -0.118$$

$$h(-1) = 0.189$$

$$h(0) = 0.367$$

$$h(1) = 0.189$$

$$h(2) = -0.118$$

$$h(3) = -0.207$$

$$\text{So } b_0 = h(-3) = -0.207$$

$$b_1 = h(-2) = -0.118$$

$$b_2 = h(-1) = 0.189$$

$$b_3 = h(0) = 0.367$$

$$b_4 = h(1) = 0.189$$

$$b_5 = h(2) = -0.118$$

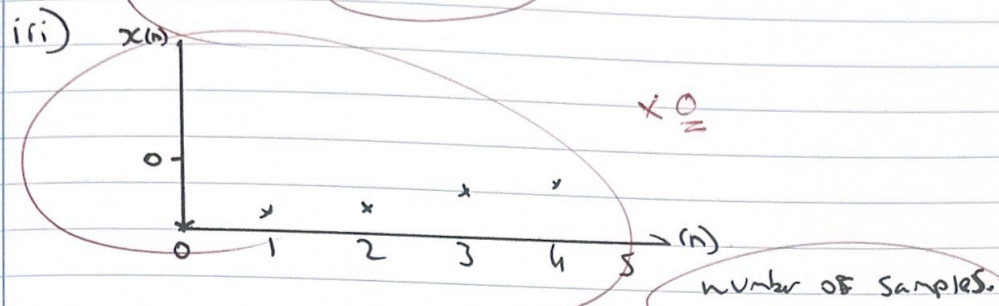
$$b_6 = h(3) = -0.207$$

b. i) multiplexing is

Q4b

0/15

2a ii) $x(n) = 0.025 \times 4 \quad u(n) = -0.1$



Q2a

1000