

12 Pages

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SURNAME:

Chartier - Roberts

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7	Number of Answer Books handed in	1

[illegible]

Template for Question 1 (Insert in Answer Booklet if used)

1	-1	0	1	2	3	4	5	6	7	8	9	10	11			
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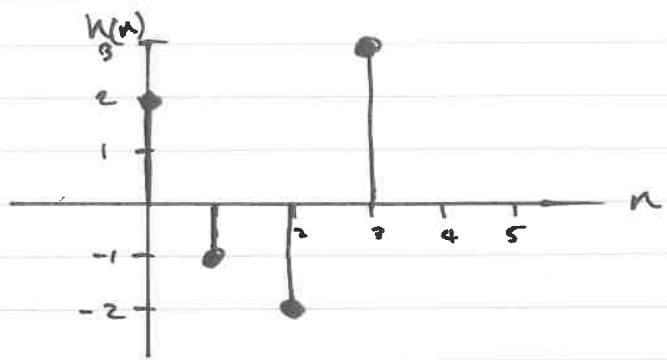
$x(n)$	2	-1	2	-1												
$h(n)$	2	-1	-2	3												
$h(n)x(n)$	4	-1	-4	-3												
$h(n)x(n-1)$	0	4	-2	4	-2							X				
$h(n)x(n-2)$	0	0	-2	1	-2	1						X				
$h(n)x(n-3)$	0	0	0	-4	2	-4	2					X				
$h(n)x(n-4)$	0	0	0	0	6	-3	6	-3				X				
$y(n)$	4	3	-8	-2	4	-6	8	-3								

[illegible]

Student Name: Gauvain Jay Chartier-Roberts

① $h(n)$ 2, -1, -2, 3

a)

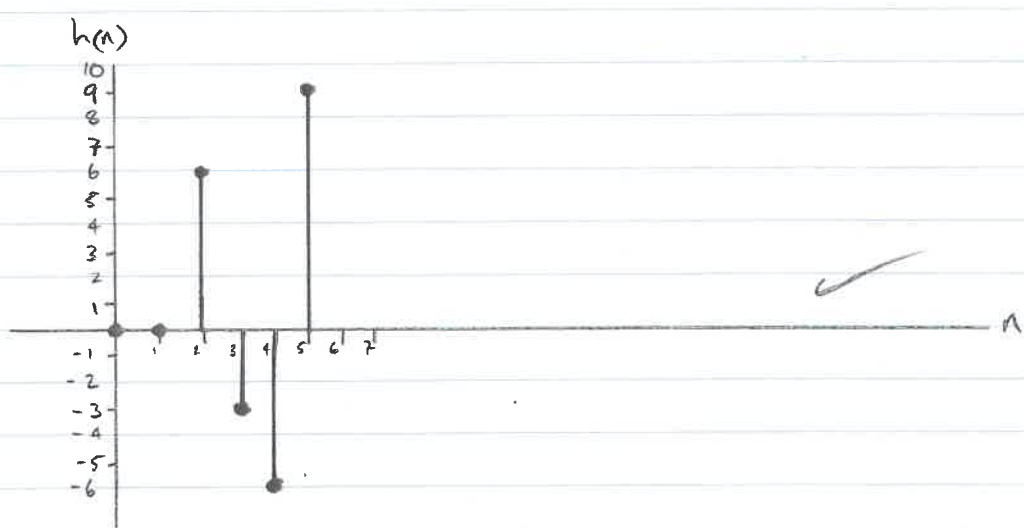


① ✓

b)

n	-1	0	1	2	3	4	5	6	7
$h(n)$	0	2	-1	-2	3	0	0		
$h(n-1)$	0	0	2	-1	-2	3	0		
$h(n-2)$	0	0	0	2	-1	-2	3		
$3h(n-2)$	0	0	0	6	-3	-6	9		

$3h(n-2) = [6, -3, -6, 9]$ ✓



③ ✓

c) $x(n) = [2, -1, 2, -1]$

From template

$y(n) = [4, 3, -8, -2, 4, -6, 8, -3]$ ✓

③ ✓

$$\begin{aligned}
 2 \quad f_p &= 10000 \text{ Hz} \\
 \Delta f &= 300 \text{ Hz} \\
 A_p &= 0.1 \text{ dB} \\
 A_s &= 50 \text{ dB} \\
 f_s &= 40000 \text{ Hz}
 \end{aligned}$$

$$a) \delta_p = \text{Log}_{10}^{-1} \left[\frac{0.1}{20} \right] - 1$$

$$= 0.011579 \quad \checkmark$$

$$\delta_s = \text{Log}_{10}^{-1} \left[\frac{-50}{20} \right]$$

$$= 0.003162 \quad \checkmark$$

Normalised pass band f

$$F_p = \frac{f_p}{f_s}$$

$$\begin{aligned}
 F_p &= \frac{10000}{40000} \\
 &= 0.25 \text{ Hz} \quad \checkmark
 \end{aligned}$$

Normalised trans. band f

$$\Delta F = \frac{\Delta f}{f_s}$$

$$\begin{aligned}
 \Delta F &= \frac{300}{40000} \\
 &= 0.0075 \text{ Hz} \quad \checkmark
 \end{aligned}$$

$$F_c = F_p \times \frac{\Delta F}{2}$$

$$F_c = 0.25 \times \frac{0.0075}{2}$$

ERROR IN CALC FOR F_c $\checkmark$

$$F_c = 0.0009375 \quad \checkmark$$

From Table 4.3, a minimum stop band attenuation of -50dB indicates a Hamming window function is suitable

$$\therefore \Delta F = \frac{3.3}{N} \quad N = \frac{3.3}{0.0075} \quad N = 440$$

Number of taps must be odd, $\therefore 440 \Rightarrow 441$ Taps

b) $h(n)$ for $n=6$ = Impulse $\times$ Window ✓

Low pass filter $n=6$

$$2F_c \frac{\sin(n\Omega_c)}{n\Omega_c} \quad \checkmark \quad \text{where } \Omega_c = 2\pi F_c$$

$$F_c = 0.0009375$$

$$(2 \times 0.0009375) \times \frac{\sin(6 \times 2\pi \times 0.0009375)}{(6 \times 2\pi \times 0.0009375)}$$

$$= 0.001875 \times \frac{\sin(0.035342)}{0.035342}$$

$$= 0.001875 \times 0.000617$$

$$= 3.2725 \times 10^{-5}$$

(method correct - allowing for carried error) ✓

Hanning window function $n=6$

$$0.54 - 0.46 \cos \left[\frac{2\pi \times 6}{441 - 1} \right]$$

$$\therefore 0.54 - 0.46 \cos \left[\frac{37.6991}{440} \right] \quad \checkmark$$

$$= 0.54 - 0.46 \cos 0.08568 \quad \checkmark$$

$$= 0.54 - 0.45999 \quad \checkmark$$

$$= 0.08 \quad \checkmark$$

Therefore for $h(n)$ when $n=6$:

$$0.08 \times 3.2725 \times 10^{-5}$$

$$h(6) = 2.618 \times 10^{-6} \quad \checkmark$$

This is the coefficient for the 6th tap.



3

Received code: 1 0 1 0 0 1 1 0 1 0 0 1

incorrect, (circled around the 4th bit '0')

- a)
- Parity bit 1 = 3 odd ✓ set as 1 - calls for odd
 - Parity bit 2 = 4 even ✓ set as 0 - calls for even
 - Parity bit 4 = 1 ~~even~~ odd ✗ set as 1 - calls for even
 - Parity bit 8 = 3 odd ✓ set as 1 - calls for odd

(4) (3) ✓

gives Original code: 1 0 0 1 0 1 0 0 0 1

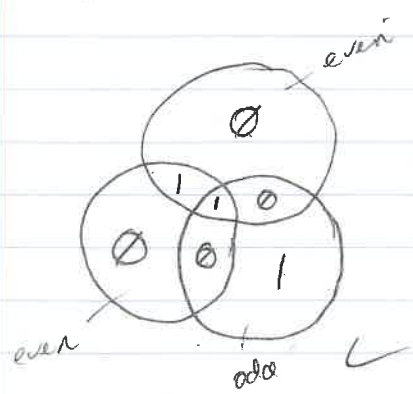
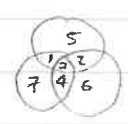
Transmission should be:

1 0 1 1 0 0 1 1 0 1 0 0 0 1 ✗

This gives

- P1 = 3 odd
- P2 = 4 even
- P4 = 2 even
- P8 = 3 odd

b) 7/4 code to 1 0 1 0



So 1 0 1 0 becomes

1 0 1 0 0 1 0 ✓

(4) ✓

$$4 \quad x(t) = 3 \cos(2000\pi t) + 6 \cos(14000\pi t) - 4 \sin(4000\pi t)$$

$f=1000$ $f=7000$ $f=2000$

a) Minimum sample rate = highest frequency $\times 2$

from $6 \cos(14000\pi t)$

$$\text{Frequency} = \frac{14000}{2} = 7000 \text{ Hz}$$

$$\therefore \text{min sample rate should be } 7000 \text{ Hz} \times 2 = 14000 \text{ Hz}$$

b) DT signal at 6000 Hz

$$x(t) = 3 \cos\left(\frac{2000\pi n}{6000}\right) + 6 \cos\left(\frac{14000\pi n}{6000}\right) - 4 \sin\left(\frac{4000\pi n}{6000}\right)$$

$$= 3 \cos\left(\frac{1}{6} 2\pi n\right) + 6 \cos\left(\frac{7}{6} 2\pi n\right) - 4 \sin\left(\frac{2}{3} \pi n\right)$$

$$x(t) = 9 \cos \frac{3}{2} \pi t - 4 \sin \frac{2}{3} \pi t$$

c) Recoverable at 6000 Hz

$$x(t) = 9 \cos\left(\frac{3}{2} 6000 \pi t\right) - 4 \sin\left(\frac{2}{3} 6000 \pi t\right)$$

$$x(t) = 9 \cos 9000 \pi t - 4 \sin 4000 \pi t$$

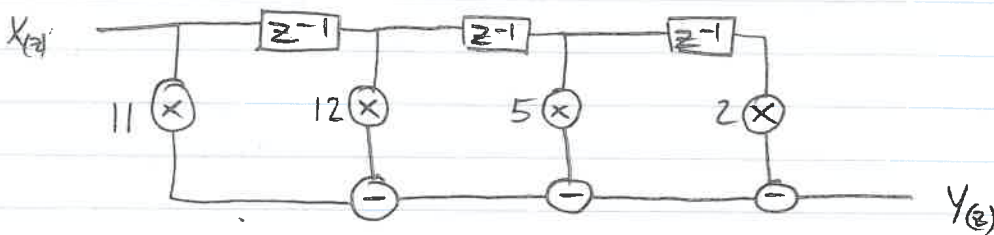
We lose the portion of the analog signal given by $6 \cos(14000\pi t)$ to aliasing - it has become indistinguishable because the sample rate of 6000 Hz was too low.

5 a) $H(z) = (3 + z^{-2})(1 - 4z^{-1})(2 + 2z^{-1})$

↓ multiply out

$$H(z) = 3 - 12z^{-1} + 6 + 6z^{-1} + z^{-2} - 4z^{-3} + 2z^{-2} + 2z^{-3} + 2 + 2z^{-1} - 8z^{-1} + 8z^{-2}$$

$$H(z) = 11 - 12z^{-1} - 5z^{-2} - 2z^{-3}$$



1 ✓

b) $a_1 = 2 \quad a_2 = 4 \quad a_3 = 2 \quad a_4 = 2 \quad a_5 = 3$

b-a) $y(n) = 2y(n-1) + 3y(n-2) + 2(x(n-1) + 4x(n-2))$ from diagram

↓ Z transform

$$Y(z) = 2Y(z)z^{-1} + 3Y(z)z^{-2} + 4X(z)z^{-1} + 8X(z)z^{-2}$$

5 ✓

-b) $Y(z) = 2Y(z)z^{-1} + 3Y(z)z^{-2} + 4X(z)z^{-1} + 8X(z)z^{-2}$

↓ rearrange

$$Y(z) - 2Y(z)z^{-1} - 3Y(z)z^{-2} = 4X(z)z^{-1} + 8X(z)z^{-2}$$

$$Y(z)(1 - 2z^{-1} - 3z^{-2}) = X(z)(4z^{-1} + 8z^{-2})$$

3 ✓

∴ Transfer function = $\frac{\text{Output}}{\text{input}} = \frac{Y(z)}{X(z)}$

$$\therefore \frac{Y(z)}{X(z)} = \frac{1 + 4z^{-1} + 8z^{-2}}{1 - 2z^{-1} - 3z^{-2}}$$