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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.
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5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
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1	Student Number	2110765
2	Title of Examination Paper	ADVANCED DIGITAL SIGNAL PROCESSING SYSTEM
3	Module Code	ACDA6018
4	Date and Time of Examination	08.01.2025 1200
5	Examination Venue	1Q310
6	Seat Number	056
7	Number of Answer Books handed in	1

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List the numbers of the questions you have attempted	Office Use
1	04 ✓
2	11 ✓
3	13 ✓
4	17 ✓
Q1	4
Q2	11
Q3	13
Q4	17
Total	45/100

45
100

12/01/25

1-a ANS: C $F(j\omega) = 2 \cdot \text{sinc}(\omega) + 4 \cdot \text{sinc}(2\omega)$

2

(2)

 $\frac{04}{25}$

1-b Ans: b $f(t-2)e^{jt} \xleftrightarrow{f_T} \frac{1}{(\omega-1)^2+1} e^{\frac{-2(\omega-1)^2}{(\omega-1)^2+1} - j2(\omega-1)}$

2

(2)

$$Q_1 = 2+2=4$$

2-a DFT of $x(n) = \begin{cases} \frac{1}{5}, & \text{for } -1 \leq n \leq 1 \\ 0, & \text{otherwise} \end{cases}$

Ans: $\left\{ \frac{1}{2}, -\frac{1}{2} - \frac{1}{2}j, \frac{1}{2}, -\frac{1}{2} + \frac{1}{2}j \right\}$

formula: $X(k) = \sum_{n=-\infty}^{\infty} x(n) e^{-j\omega n}$ at $\omega = \frac{2\pi k}{N}$ $k=0, 1, \dots, N-1$

2-b: Hamming window

formula: $w(n) = 0.54 - 0.46 \cos\left(\frac{2\pi n}{N-1}\right)$

$y(n) = w(n) \cdot x(n)$

$x(n) = \{12.5, 8, 8, 12.5\}$

$n=0 = 0.54 - 0.46 \cos\left(\frac{2\pi \cdot 0}{3}\right) = 0.08$

$n=1 = 0.54 - 0.46 \cos\left(\frac{2\pi \cdot 1}{3}\right) = 0.77$

$n=2 = 0.54 - 0.46 \cos\left(\frac{2\pi \cdot 2}{3}\right) = 0.77$

$n=3 = 0.54 - 0.46 \cos\left(\frac{2\pi \cdot 3}{3}\right) = 0.08$

$y(n) = w(n) \cdot x(n)$

$n=0 = 0.08 \cdot 12.5 = 1$

$n=1 = 0.77 \cdot 8 = 6.16$

$n=2 = 0.77 \cdot 8 = 6.16$

$n=3 = 0.08 \cdot 12.5 = 1$

$y(n) = \{1, 6.16, 6.16, 1\}$

$\sigma_2 = 1+1+4+4+1 = 11$

3-ai

$$I(t) = S(t) \cdot LO \text{ Q-PHASE}$$

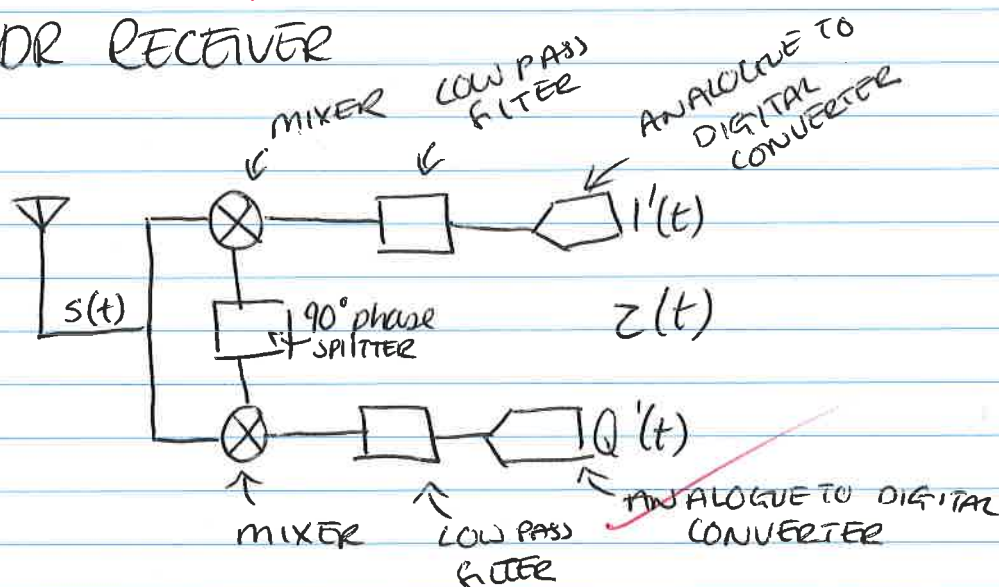
$$Q(t) = S(t) \cdot LO \text{ INPHASE}$$

$$I'(t) = \cos(2\pi(1200) \cancel{t} 50 + \frac{\pi}{4})t$$

$$Q(t) = -\sin(2\pi(1200) \cancel{t} 50 + \frac{\pi}{4})t$$

$$Z(t) = I'(t) \cdot Q(t)$$

3-aii SDR RECEIVER



3-aiii The RF input is converted into its baseband representation by mixing, which produces a sum frequency & a difference frequency, which after going through a lowpass filter the high frequency components are removed, leaving the desired 50 Hz

Sum: $f_{RF} + f_{LO}$
 difference: $f_{RF} - f_{LO}$

3-bi ~~interference~~ interference = 1230
 $L_0 = 1150$

Sum frequency = $f_{\text{INT}} + f_{L_0}$
 $= 1230 + 1150 = \underline{2380\text{Hz}}$

difference freq. = $f_{\text{INT}} - f_{L_0} = \underline{80\text{Hz}}$

ANS: 80Hz would be retained in the baseband.

3-bii interference causes the ^{output} ~~freq~~ frequency to be shifted, causing the amplitude & phase to be shifted, degrading the signal integrity

without interference the desired 50Hz is retained with the correct amplitude & phase.

3-biii To recover the desired frequency the following can be done.

- ~~30Hz cut off~~
- use a high order filter such as Butterworths, chebyshevs, FIR filters
- Cut off frequency just above the desired frequency, e.g. 55-60Hz for 50Hz
- Use a filter with a steep roll off.

$Q_3 = 1+4+2+1+2+3 = 13$

$\frac{13}{25}$

Q-4a $y(n) = \{1, 2, 3, 4, 4, 3, 2, 1\}$
_{0 1 2 3 4 5 6 7}

4-ai Even terms $\{1, 3, 4, 2\} = \{1, 4\} \{3, 2\}$
 odd terms $\{2, 4, 3, 1\} = \{2, 3\} \{4, 1\}$

4-aii Twiddle factors

formula = $W_N^k = e^{-j \frac{2\pi}{N} k}$

$N = 8$ $K = 0, 1, 2, 3$

$K=0 = W_8^0 = e^{-j \frac{2\pi}{8} 0} = 1$

$K=1 = W_8^1 = e^{-j \frac{2\pi}{8} 1} = 0.707 - 0.707j$

$K=2 = W_8^2 = e^{-j \frac{2\pi}{8} 2} = -j$

$K=3 = W_8^3 = e^{-j \frac{2\pi}{8} 3} = -0.707 - 0.707j$

4-aii

4-b

$(2-3j)(0.707-0.707j) + (-2-j) = 1.535 - 5.535j$

$(-4-4j)(0.707-0.707j) + (-4-j) =$

ϵ

$-4 \times -0.707 = 2.828$

$-4 \times -0.707j = 2.828j$

$-4j \times -0.707 = 2.828j$

$-4j \times -0.707j = 2.828$

$= 0 + 5.656j + (-4-j) = -4 + 5.656j$

$Q_{11} = 2+2+13 = 17$

$\frac{17}{25}$

4-b
cont.

$$(2-3j)(0.707-0.707j)$$

$$2 \times 0.707 = 1.414$$

$$2 \times -0.707j = -1.414j \quad = 0.707 - 3.535j$$

$$-3j \times 0.707 = -2.121j$$

$$-3j \times -0.707j = -2.121$$

$$(-2-j) - (0.707 - 3.535j) = 2.707 - 3.535j$$

$$(-2-j) - (2-3j)(0.707-0.707j)$$

$$2 \times 0.707 = 1.414$$

$$2 \times -0.707j = -1.414j \quad -0.707 - 3.535j$$

$$-3j \times 0.707 = -2.121j$$

$$-3j \times -0.707j = -2.121$$

$$(2-j) - (-0.707 - 3.535j) = 2.707 - 3.535j$$

$$(-4-j) - (-4-4j)(0.707-0.707j)$$

$$-4 \times -0.707 = 2.828$$

$$-4 \times -0.707j = 2.828j \quad 0 + 5.656j$$

$$-4j \times -0.707 = 2.828j$$

$$-4j \times -0.707j = -2.828$$

$$-4j(-4-j) - (0 + 5.656j) = -4 + 5.656$$

$$\text{ANS: } Y(k) = \{2.0, 1.535 - 4.535j, 0, -4 + 5.656j, 0, 2.707 - 3.535j, 0, -4 + 5.656j\}$$

$$(2-2j)(0.707-0.707j)$$

$$2 \times 0.707 = 1.414$$

$$2 \times -0.707j = -1.414j \quad 0 - 2.828j + -2-j = -2-2.828j$$

$$-2j \times 0.707 = -1.414j$$

$$-2j \times -0.707j = -1.414$$

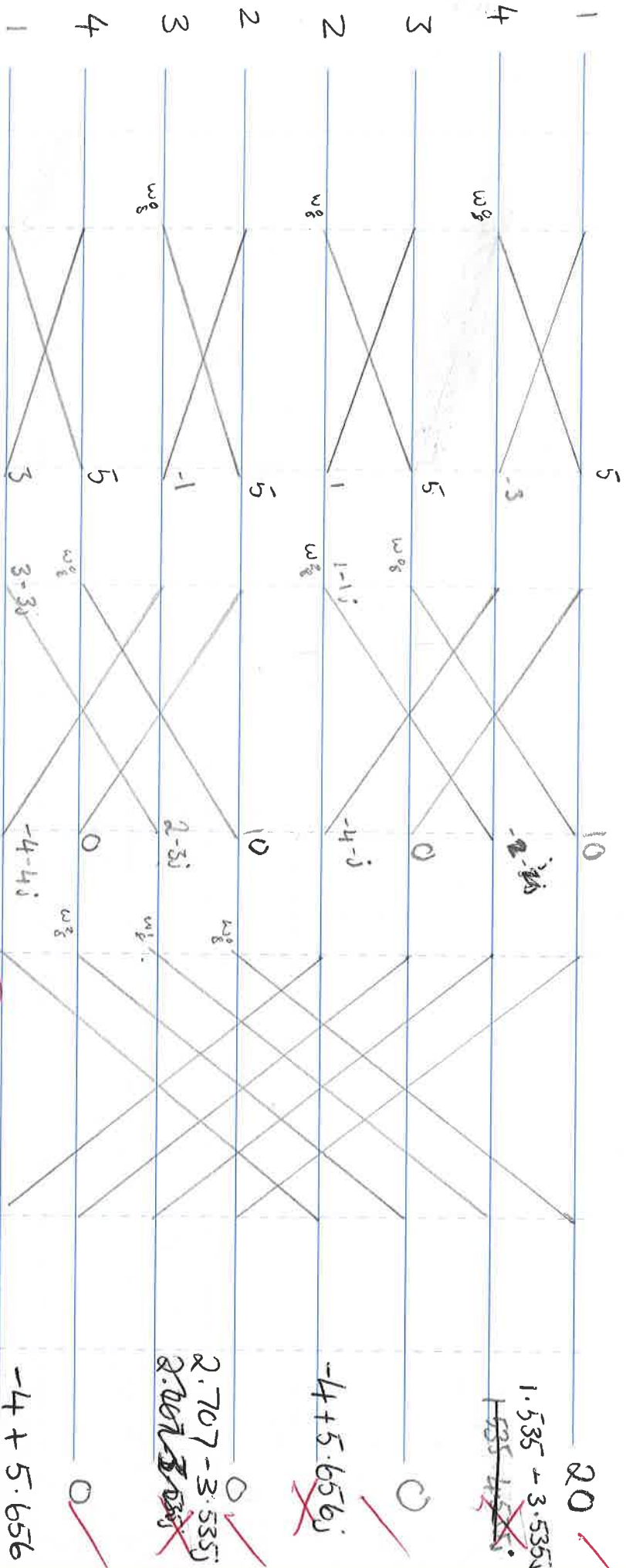
$$-2j \times -0.707j = -1.414$$

forward

5

$y(k)$

$y(k)$



$\omega_8^0 = 1$
 $\omega_8^1 = 0.707 - 0.707j$
 $\omega_8^2 = -j$
 $\omega_8^3 = -0.707 - 0.707j$

$(2-3j)(0.707-0.707j) + (-2-j)$
 $1.414 - 1.414j - 2.121j + 1.212$
 $3.535 - 3.535j + (-2-j) = 1.535 - 4.535j$

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