



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.
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).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

1	Student Number	2111739
2	Title of Examination Paper	Advanced Digital Signal Processing System
3	Module Code	ACDA6018
4	Date and Time of Examination	8th January 2025 12:00 PM
5	Examination Venue	1Q 310
6	Seat Number	059
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
Q1	08
Q2	03
Q3	17
Q4	12
Q1	8
Q2	3
Q3	17
Q4	12
Total	40/100

1) a) $f(t) = \begin{cases} 2 & \text{for } -1 \leq t \leq 1 \\ 1 & \text{for } -2 \leq t < -1 \\ 1 & \text{for } 1 \leq t < 2 \\ 0 & \text{otherwise} \end{cases}$ (Define $f(t)$)

Answer = C

Function is even, so all b_n terms = 0.

No DC term, so $a_0 = 0$.

$$a_n = \frac{2}{T} \int_{-2}^{-1} 1 \cdot \cos n\omega_0 t dt + \int_{-1}^1 2 \cdot \cos n\omega_0 t dt + \int_1^2 1 \cdot \cos n\omega_0 t dt$$

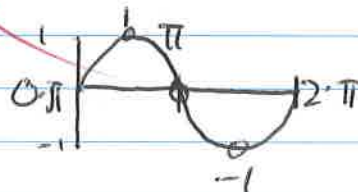
(Apply a_n formula)

$$a_n = \frac{2}{T} \left(\left[\frac{\sin(n\omega_0 t)}{n\omega_0} \right]_{-2}^{-1} + \left[\frac{2 \sin(n\omega_0 t)}{n\omega_0} \right]_{-1}^1 + \left[\frac{\sin(n\omega_0 t)}{n\omega_0} \right]_1^2 \right)$$

(integrate)
(apply limits)

$$a_n = \frac{2}{T} \left(\left[\frac{\sin(-n\omega_0)}{n\omega_0} \right] - \left[\frac{\sin(-2n\omega_0)}{n\omega_0} \right] + \left[\frac{2 \sin(2n\omega_0)}{n\omega_0} \right] - \left[\frac{2 \sin(n\omega_0)}{n\omega_0} \right] + \left[\frac{\sin(2n\omega_0)}{n\omega_0} \right] - \left[\frac{\sin(n\omega_0)}{n\omega_0} \right] \right)$$

(collect like terms)



$$a_n = \frac{2}{T} \left(\frac{\sin(-n\omega_0)}{n\omega_0} - \frac{\sin(-2n\omega_0)}{n\omega_0} + \frac{2 \sin(2n\omega_0)}{n\omega_0} - \frac{2 \sin(n\omega_0)}{n\omega_0} + \frac{\sin(2n\omega_0)}{n\omega_0} - \frac{\sin(n\omega_0)}{n\omega_0} \right)$$

$$a_n = \frac{2}{T} \left(\frac{\sin(-n\omega_0)}{n\omega_0} - \frac{\sin(-2n\omega_0)}{n\omega_0} + \frac{2 \sin(2n\omega_0)}{n\omega_0} - \frac{2 \sin(n\omega_0)}{n\omega_0} + \frac{\sin(2n\omega_0)}{n\omega_0} - \frac{\sin(n\omega_0)}{n\omega_0} \right)$$

$$a_n = \frac{2}{T} \left(-\sin(n\omega_0) + \sin(2n\omega_0) + 2 \sin(2n\omega_0) - 2 \sin(n\omega_0) + \sin(2n\omega_0) - \sin(n\omega_0) \right)$$

$\sin(x) = -\sin(-x)$

$$a_n = \frac{2}{T} \left(\sin(-n\omega_0) - \sin(-2n\omega_0) + 2 \sin(2n\omega_0) - 2 \sin(n\omega_0) + \sin(2n\omega_0) - \sin(n\omega_0) \right)$$

$$a_n = \frac{2}{T} \left(2 \sin(2n\omega_0) - 2 \sin(n\omega_0) \right)$$

$a_n = \frac{2}{T}$



$$a_n = \frac{2}{n\omega_0 T} (4 \sin(2n\omega_0) - 2 \sin(n\omega_0)) \quad a_n = \frac{2}{2\pi n} = \frac{1}{\pi n} (4 \sin$$

$$a_n = \frac{2}{T} \left(\frac{4 \sin(2n\omega_0)}{n\omega_0} - \frac{2 \sin(n\omega_0)}{n\omega_0} \right)$$

$$a_n = \frac{2}{T} (4 \sin(2n\omega_0) + 2 \sin(n\omega_0)) \quad T = \frac{2\pi}{\omega}$$

$$R_n = \frac{1}{\pi}$$

①

~~00/20~~

1b

Answer: B

$$\frac{1}{\omega^2+1} e^{-\frac{2\omega^2}{\omega^2+1}} e^{j2\omega}$$

$$t_0 = -2$$

$$f(t-t_0) \xrightarrow{FT} F(j\omega) e^{-j\omega t_0}$$

$$\frac{1}{(\omega-1)^2+1} e^{-\frac{2(\omega-1)^2}{(\omega-1)^2+1}} e^{j2\omega}$$

$$\omega_0 = 1$$

$$f(t) e^{j\omega_0 t} \xrightarrow{FT} F(j\omega - j\omega_0)$$

$$(\omega-1)^2+1 = \omega^2+1$$

$$\frac{1}{(\omega-1)^2+1} e^{-\frac{2(\omega-1)^2}{(\omega-1)^2+1}} e^{-j2(\omega-1)}$$

$$Q = 4+4=8$$

(4)

1 ✓

1 ✓

2 ✓

$$\frac{108}{20}$$

2a $x(n) = 1/5$, for $-1 \leq n \leq 1$
 0 , otherwise



$$X(k) = x(n) e^{-j\pi kn/N}$$

$$X(k) = x(n) e^{-j\pi \cdot kn/4}$$

4 point DFT

$$X(0) = x(n) e^{-j\pi \cdot 0 \cdot n/4} \\ = x(0)$$

$$x(n) = \frac{1}{4}$$

$$x(n)$$

$$X(k) = x(n) e^{-j(2\pi kn/N)}$$

$$x(n) = \frac{1}{N} \sum_{k=0}^{N-1}$$

(Handwritten signature/initials in a circle)

2bi Ideal FIR filters could be used to remove unwanted frequencies from a signal.

2bii $x(n) = \{12.5, 8, 8, 12.5\}$

~~$h_d(h) = \frac{1}{2\pi} \int_{-\pi}^{\pi} H_d(e^{j\omega}) e^{j\omega n} d\omega$~~

~~$N=4$~~

$w(n) = 0.54 - 0.46 \cos\left(\frac{2\pi n}{N-1}\right)$ $N=4$

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

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

$w(1) = 0.54 - 0.46 \cos\left(\frac{2\pi(1)}{3}\right) = -0.5$

$w(2) = 0.54 - 0.46 \cos\left(\frac{2\pi(2)}{3}\right) = -0.5$

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

$w(n) = \{1, -0.5, -0.5, 1\}$

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

$y(n) = \{12.5, -4, -4, 12.5\}$

$q_2 = 1+2 = 3$

08
25

$$3a) S(t) = 3 \cos(120^\circ)$$

$$S(t) = 3 \cos(2\pi \cdot 1200 + \pi/6)$$

$$LO_{\text{INPHASE}} = 2 \cos(2\pi \cdot 1150)$$

$$LO_{\text{Q-PHASE}} = -2 \sin(2\pi \cdot 1150)$$

$$I(t) = S(t) \cdot LO_{\text{INPHASE}} \quad Q(t) = LO_{\text{Q-PHASE}} \quad Z(t) = I(t) + Q(t)$$

$$I(t) = \frac{1}{2} [6 \cdot (\cos(2\pi \cdot 2350 + \pi/6) + \cos(2\pi \cdot 50 + \pi/6))]$$

$$I(t) = 3 [\cos(2\pi \cdot 2350 + \pi/6) + \cos(2\pi \cdot 50 + \pi/6)]$$

$$Q(t) = \frac{1}{2} [-6 (\sin(2\pi \cdot 2350 + \pi/6) - \sin(2\pi \cdot 50 + \pi/6))]$$

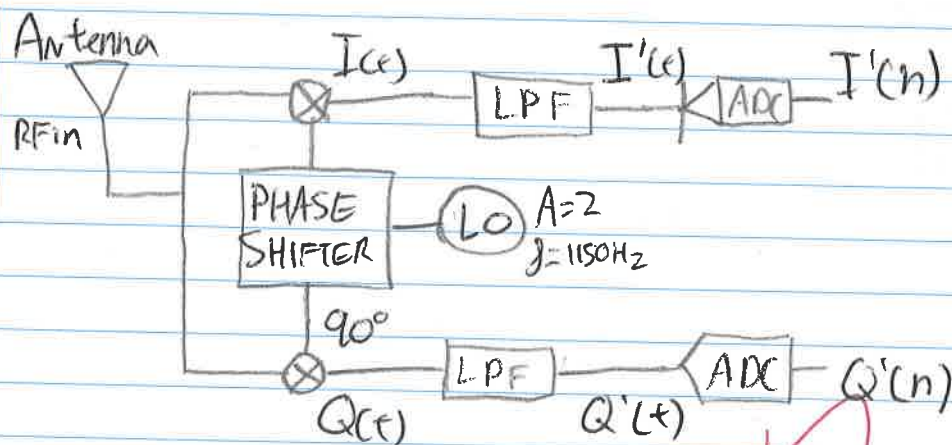
$$Q(t) = -3 [\sin(2\pi \cdot 2350 + \pi/6) - \sin(2\pi \cdot 50 + \pi/6)]$$

$$Z(t) = 3 [\cos(2\pi \cdot 2350 + \pi/6) + \cos(2\pi \cdot 50 + \pi/6) - \sin(2\pi \cdot 2350 + \pi/6) + \sin(2\pi \cdot 50 + \pi/6)]$$

The narrow band interference may be removed by using a Low pass filter ?

0

3a ii



3a iii

The antenna receives an RF signal. The Phase Shifter removes the carrier frequency by using mixing in the local oscillator. The resultant signal is taken by using a low pass filter to get I and Q in baseband frequencies.

3b i

The resulting frequencies are 2380 Hz and 80 Hz. A low pass filter should retain frequencies under 80 Hz to avoid all interference at 1230 Hz.

3b ii

Interference adds in an undesired signal to the original message, and if the strength is high, the original message signal cannot be recovered. This interference appears as an additional frequency component in the output.

3b iii

A band pass filter may be used to remove frequencies. A low pass filter can be adjusted to remove interference. Frequency hopping can be used to move away from interference to a different carrier frequency which does not have nearby narrowband interference.

$$Q_3 = 4 + 2 + 2 + 4 + 2 + 2 + 1 = 17$$

18
25

4a i $y(n) = [1, 2, 3, 4, 4, 3, 2, 1]$

even = $[1, 3, 4, 2]$

odd = $[2, 4, 3, 1]$

even even = $[1, 4]$

even odd = $[3, 2]$

odd even = $[2, 3]$

odd odd = $[4, 1]$

$y(0) \ y(4)$

$y(2) \ y(6)$

$y(1) \ y(7)$

$y(3) \ y(5)$

0
4
2
6
1
5
3
7

2
(2)

4a ii Twiddle factors

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

$W_8^0 = e^{-j0} = 1$

$W_8^1 = e^{-j\frac{2\pi}{8}} = 0.707 - j0.707$

$W_8^2 = e^{-j\frac{4\pi}{8}} = -1$

$W_8^3 = e^{-j\frac{6\pi}{8}} = -0.707 - j0.707$

2
(2)

12
25

$2n = 4 + 8 = 12$

(8)

format

(1)

(4)

