



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 the paper 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	2114468
2	Title of Examination Paper	Advanced Digital signal processing Systems
3	Module Code	AECA6018
4	Date and Time of Examination	08/01/2025 12:00 Noon
5	Examination Venue	IQ 307
6	Seat Number	-
7	Number of Answer Books handed in	1

List the numbers of the questions you have attempted	Office Use
Q1	18
Q2	16
Q3	20
Q4	25
Q1	18
Q2	16
Q3	20
Q4	25
Total	79/100

Q1) A)

$$f(t) = \begin{cases} 2, & -1 < t < 1 \\ 1, & -2 < t < -1 \\ 1, & 1 < t < 2 \end{cases}$$

$$\int e^{-j\omega t} dt = \frac{e^{-j\omega t}}{-j\omega}$$

$$f(t) = \int_{-1}^1 2e^{-j\omega t} dt + \int_{-2}^{-1} e^{-j\omega t} dt + \int_1^2 e^{-j\omega t} dt$$

$$f(t) = \left[\frac{2e^{-j\omega t}}{-j\omega} \right]_{-1}^1 + \left[\frac{e^{-j\omega t}}{-j\omega} \right]_{-2}^{-1} + \left[\frac{e^{-j\omega t}}{-j\omega} \right]_1^2$$

$$f(t) = \left[\frac{2e^{-j\omega(1)} - 2e^{-j\omega(-1)}}{-j\omega} \right] + \left[\frac{e^{-j\omega(-1)} - e^{-j\omega(-2)}}{-j\omega} \right] + \left[\frac{e^{-j\omega(2)} - e^{-j\omega(1)}}{-j\omega} \right]$$

$$f(t) = \left[\frac{2e^{-j\omega} - 2e^{j\omega}}{-j\omega} \right] + \left[\frac{e^{j\omega} - e^{j2\omega}}{-j\omega} \right] + \left[\frac{e^{-j2\omega} - e^{-j\omega}}{-j\omega} \right]$$

$$f(t) = \frac{1}{-j\omega} \left\{ [2e^{-j\omega} - 2e^{j\omega}] + [e^{j\omega} - e^{j2\omega}] + [e^{-j2\omega} - e^{-j\omega}] \right\}$$

$$f(t) = \frac{1}{-j\omega} \left\{ \left[\frac{2}{2} \cdot 2e^{-j\omega} - \frac{2}{2} \cdot 2e^{j\omega} \right] + \left[\frac{2}{2} e^{j\omega} - \frac{2}{2} e^{j2\omega} \right] + \left[\frac{2}{2} e^{-j2\omega} - \frac{2}{2} e^{-j\omega} \right] \right\}$$

$$f(t) = \frac{1}{j\omega} \left\{ \left[-\frac{4}{2} e^{-j\omega} + \frac{4}{2} e^{j\omega} \right] + \left[\frac{2}{2} e^{j\omega} - \frac{2}{2} e^{j2\omega} \right] - \left[\frac{2}{2} e^{-j2\omega} - \frac{2}{2} e^{-j\omega} \right] \right\}$$

$$f(t) = \frac{1}{j\omega} \left\{ \left[\frac{4}{2} e^{j\omega} - \frac{4}{2} e^{-j\omega} + \frac{2}{2} e^{j2\omega} - \frac{2}{2} e^{-j2\omega} - \frac{2}{2} e^{j\omega} + \frac{2}{2} e^{-j\omega} \right] \right\}$$

$$f(t) = \frac{1}{\omega} \left\{ \left[\frac{4(e^{j\omega} - e^{-j\omega})}{2j} + \frac{2(e^{j2\omega} - e^{-j2\omega})}{2j} - \frac{2(e^{j\omega} + e^{-j\omega})}{2j} \right] \right\}$$

$$f(t) = \frac{1}{\omega} \left\{ 4 \cos(\omega) + 2 \cos(2\omega) - \{2 \cos(\omega)\} \right\} \quad e^{j\omega} + e^{-j\omega} = 2 \cos \omega$$

$$f(t) = \frac{1}{\omega} \left\{ 2 \cos(\omega) + 2 \cos(2\omega) \right\}$$

$$f(t) = \frac{1}{\omega} \left\{ 2 \cos(\omega) + \frac{2}{2} \cdot 2 \cos(2\omega) \right\} \quad \text{Second by } \frac{2}{2}$$

$$f(t) = \left\{ \frac{2 \cos(\omega)}{\omega} + \frac{4 \cos(2\omega)}{2\omega} \right\}$$

$$f(t) = 2 \text{Sinc}(\omega) + 4 \text{Sinc}(2\omega) \therefore$$

$$\text{Answer C. } F(j\omega) = 2 \text{Sinc}(\omega) + 4 \text{Sinc}(2\omega) \therefore$$

Q1) B)

$$F(j\omega) = \frac{1}{\omega^2 + 1} e^{\frac{-2\omega^2}{(\omega^2 + 1)}}$$

$$\delta(t-2)e^{jt} \leftrightarrow \frac{1}{\omega^2 + 1} e^{\frac{-2\omega^2}{(\omega^2 + 1)}} e^{-j\omega 2}$$

$$\delta(t)e^{j\omega_0 t} \leftrightarrow F(\omega - \omega_0)$$

$$\delta(t)e^{j\omega_0 t} \leftrightarrow F(\omega - 1)$$

$$\delta(t-2)e^{jt} \leftrightarrow \frac{1}{(\omega-1)^2 + 1} e^{\frac{-2(\omega-1)^2}{((\omega-1)^2 + 1)}} e^{-j2(\omega-1)}$$

$$\text{Answer b. } \delta(t-2)e^{jt} \xrightarrow{FT} \frac{1}{(\omega-1)^2 + 1} e^{-j2(\omega-1)}$$

$$Q_1 = 2+3+1+3+2+5+2$$

$$\frac{18}{25}$$

Q2) A)

DFT

$$x(n) = \begin{cases} \frac{1}{5} & -1 \leq n \leq 1 \\ 0 & \text{otherwise} \end{cases}$$

$$x(n) = \left\{ \frac{1}{5}, \frac{1}{5}, \frac{1}{5} \right\}$$

$$X(k) = \frac{1}{5} e^{-j\omega(-1)} + \frac{1}{5} e^{-j\omega(0)} + \frac{1}{5} e^{-j\omega(1)}$$

$$X(k) = \sum_{n=-\infty}^{\infty} x(n) e^{-j\omega n} \quad \omega = \frac{2\pi k}{N}$$

$$k=0, 1, 2 \\ N=3$$

$$X(k) = \frac{1}{5} (e^{j\omega} + 1 + e^{-j\omega})$$

$$X(k) = \frac{1}{5} (1 + e^{j\omega} + e^{-j\omega})$$

$$X(k) = \frac{1}{5} (1 + 2\cos(\omega))$$

$$e^{j\omega} + e^{-j\omega} = 2\cos(\omega)$$

$$X(k) = \frac{1}{5} \left(1 + 2\cos\left(\frac{2\pi k}{3}\right) \right)$$

$$\omega = \frac{2\pi k}{N} \quad N=3$$

$$k=0, 1, 2$$

Q2) 13)

- i) • If the frequency is off then the filter may let through too much noise.
 • you could use it for radio communication w/in FM or SDR transmission or receive
 • The filter tolerance may be off.

B)

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

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

$$N = 4$$

$$N-1 = 3$$

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

$$w(0) = 0.08$$

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

$$w(1) = 0.77$$

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

$$w(2) = 0.77$$

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

$$w(3) = 0.08$$

$w(n)$	$x(n)$	$y(n)$
0.08	12.5	1
0.77	8	6.16
0.77	8	6.16
0.08	12.5	1

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

$$Q_2 = 1 + 5 + 5 + 5 = 16$$

16
56

Q3) A)

i)

$$S(t) = 3 \cos\left[2\pi(1200)t + \frac{\pi}{6}\right]$$

$$L_{in} = 2 \cos[2\pi(1150)t]$$

$$L_{out} = -2 \sin[2\pi(1150)t]$$

$$\textcircled{1} \cos A \cos B = \frac{1}{2} [\cos(A+B) + \cos(A-B)]$$

$$\textcircled{2} \cos A \sin B = \frac{1}{2} [\sin(A+B) - \sin(A-B)]$$

$$I(t) = S(t) * L_{in}$$

$$Q(t) = S(t) * L_{out}$$

$$Z(t) = I'(t) + Q'(t)$$

①

$$I(t) = 3 \cos\left[2\pi(1200)t + \frac{\pi}{6}\right] + 2 \cos[2\pi(1150)t]$$

$$= \left(\frac{1}{2}\right)(6) \left[\cos\left(2\pi(1200)t + \frac{\pi}{6} + 2\pi(1150)t\right) + \cos\left(2\pi(1200)t + \frac{\pi}{6} - 2\pi(1150)t\right) \right]$$

$$I(t) = 3 \left[\cos(2\pi(2350)t + \frac{\pi}{6}) + \cos(2\pi(50)t + \frac{\pi}{6}) \right]$$

$$I'(t) = 3 \cos(2\pi(50)t + \frac{\pi}{6})$$

②

$$Q(t) = 3 \cos\left[2\pi(1200)t + \frac{\pi}{6}\right] - 2 \sin[2\pi(1150)t]$$

$$= \left(\frac{1}{2}\right)(-6) \left[\cos\left(2\pi(1200)t + \frac{\pi}{6} + 2\pi(1150)t\right) - \sin\left(2\pi(1200)t + \frac{\pi}{6} - 2\pi(1150)t\right) \right]$$

$$Q(t) = -3 \left[\cos(2\pi(2350)t + \frac{\pi}{6}) - \sin(2\pi(50)t + \frac{\pi}{6}) \right]$$

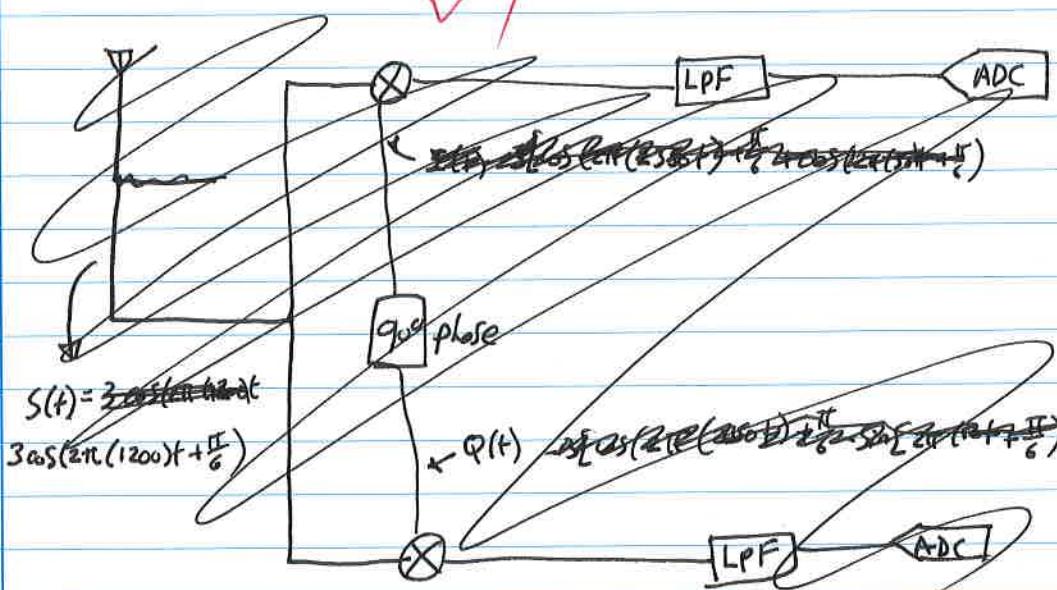
$$Q'(t) = +3 \sin(2\pi(50)t + \frac{\pi}{6})$$

$$Z(t) = 3 \cos(2\pi(50)t + \frac{\pi}{6}) + 3 \sin(2\pi(50)t + \frac{\pi}{6})$$

$$Z(t) = 6 e^{j2\pi(50)t + \frac{\pi}{6}}$$

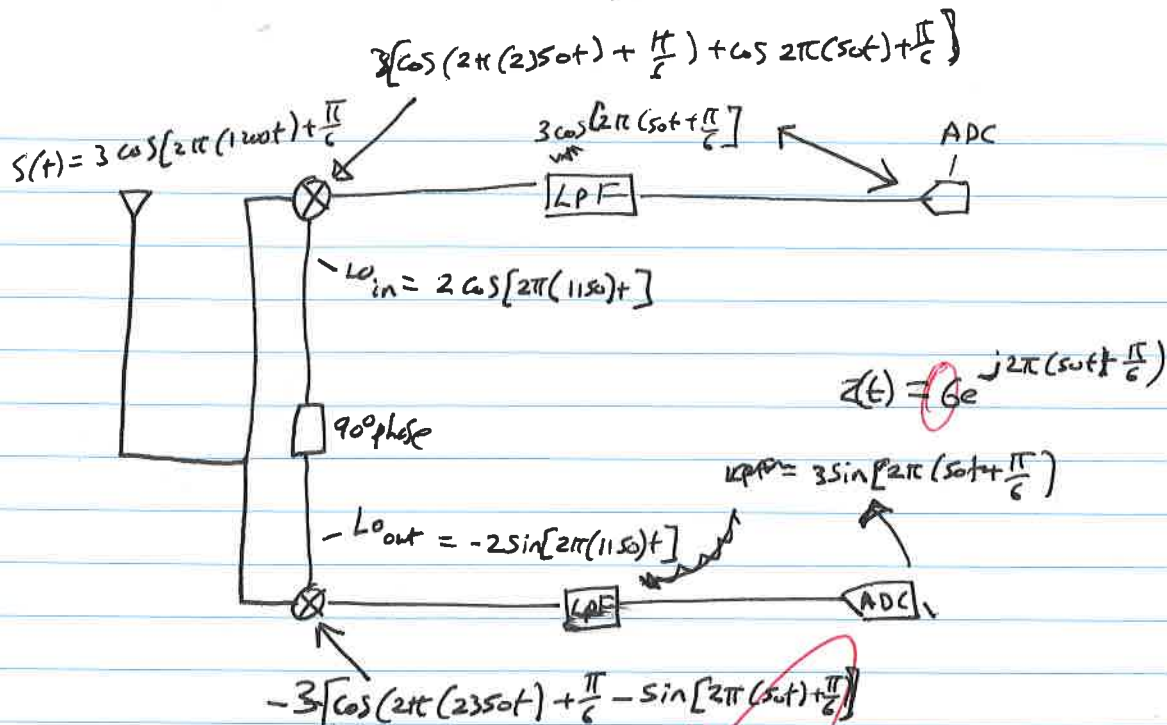
 $\therefore$

$$e^{j\theta} = \cos(\theta) + j\sin(\theta)$$



A)

ii)



A)

iii)

The addition of the local oscillator is used as a down conversion to the original RF Input Signal, producing ~~the~~ output of ~~a~~ ~~not~~ ~~and~~ ~~in~~ 2 outputs which are the baseband representation.

This

B)

i)

RF Signal = L_o Signal = 1150 Hz

Interference (t) = 1230 Hz

$$S_{interference}(t) + L_o \text{ signal} = 1230 + 1150 \text{ Hz} = 2380 \text{ Hz}$$

$$S_{interference}(t) - L_o \text{ signal} = 1230 - 1150 \text{ Hz} = 80 \text{ Hz}$$

B)

ii)

output without interference = 50 Hz

output with interference = 80 Hz

This will cause the output frequency to be shifted and unclear.

B)

iii)

If a frequency is used just above 50 Hz (around 55-60 Hz) the frequency would not be interfered due to the frequency containing the interfered frequency addition.

$$Q_3 = 3 + 3 + 3 + 2 + 4 + 1 + 2 + 2 = 20$$

Q(4)

a) i)

$$y(n) = \{1, 2, 3, 4, 4, 3, 2, 1\}$$

$$(0 \ 1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7)$$

	0	1	2	3		0	1
$y(n)$ = Even	1	3	4	2	Even Even	=	1, 4
odd	2	4	3	1	Even odd	=	3, 2
					odd Even	=	2, 3
					odd odd	=	4, 1

Sequence 1 4 3 2 2 3 4 1

Q(4)

a) ii)

$$W_N^k = e^{j\frac{2\pi}{N}k} = e^{-j\frac{2\pi}{8}k}$$

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

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

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

$$W_8^3 = e^{-j\frac{2\pi}{8}3} = -0.707 - j0.707$$

b)

Rec Butterfly diagram attached

 $x[20]$

$$x(0) = 20$$

$$x(1) = -5.828 - j2.414$$

$$x(2) = 0$$

$$x(3) = -0.172 - j0.414$$

$$x(4) = 0$$

$$x(5) = -0.172 + j0.414$$

$$x(6) = 0$$

$$x(7) = -5.828 + j2.414$$

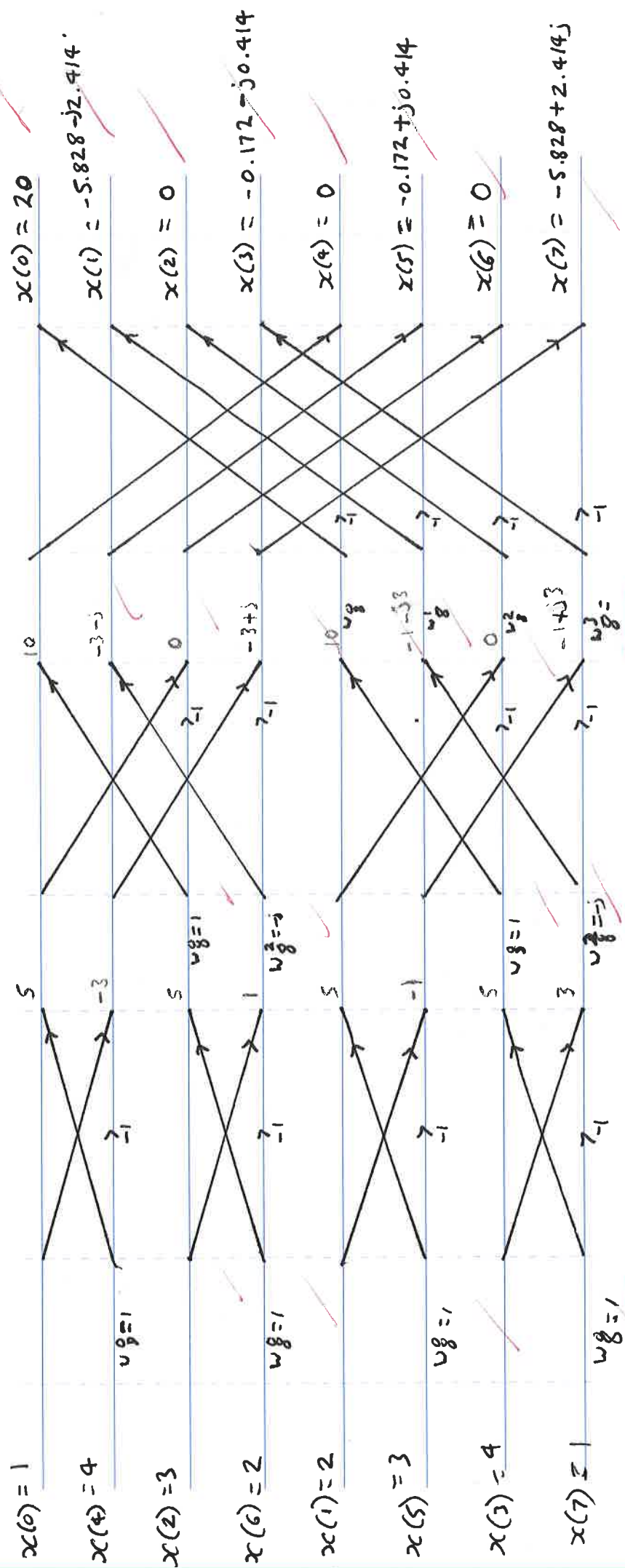
...

$$Q_4 = 2+2+16+5 = 25$$

$$\frac{25}{25}$$

$$\begin{aligned}
 v_8 &= 1 \\
 v_7 &= 0.707 - j0.707 \\
 v_6 &= -j \\
 v_5 &= -0.707 - j0.707
 \end{aligned}$$

Correct format
 ②



①

①

②

✓