



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 only read legible 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	2110763
2	Title of Examination Paper	Adv DSP
3	Module Code	ACDA6018
4	Date and Time of Examination	08/01/2025 12:00
5	Examination Venue	IQ310
6	Seat Number	062
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
Q1	12
Q2	13
Q3	20
Q4	05
Q1	12
Q2	13
Q3	20
Q4	5
Total	50/100

50
100
12/01/25

1)

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

$$f(t-2)e^{j\omega t}$$

→ time shift

Formula:

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

↓

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

Formula 2:

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

↓

$$F(j\omega - 1)$$

take ω_0 as = 1

$$\text{Answer} = \cancel{F(j\omega)} \frac{1}{(\omega-1)^2 + 1} e^{\frac{-2\omega^2}{(\omega-1)^2 + 1}} e^{-j2(\omega-1)}$$

↓

$$\text{answer} = b.)$$

①

1 ✓

2 ✓

②

1 ✓

②

2 ✓

②

12/25

Q3) i.)

$$S(t) = A \cos[2\pi f_m t + \varphi]$$

$$A = 3$$

$$f_m = 1200 \text{ Hz}$$

$$\varphi = \frac{\pi}{6}$$

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

$$LO_{\text{IN-PHASE}} = \cos[2\pi f_o t]$$

$$LO_{\text{Q-PHASE}} = -\sin[2\pi f_o t]$$

$$LO_{\text{IN-PHASE}} = \cos[2\pi(1150)t]$$

$$f_o = 1150 \text{ Hz}$$

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

$$I(t) = S(t) \cdot LO_{\text{IN-PHASE}}$$

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

Formula:

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

$$I(t) = 3 \cdot \frac{1}{2} \left[\cos[2\pi(1200+1150)t + \frac{\pi}{6}] + \cos[2\pi(1200-1150)t + \frac{\pi}{6}] \right]$$

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

$$Q(t) = S(t) \cdot LO_{Q-PHASE}$$

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

Formula:

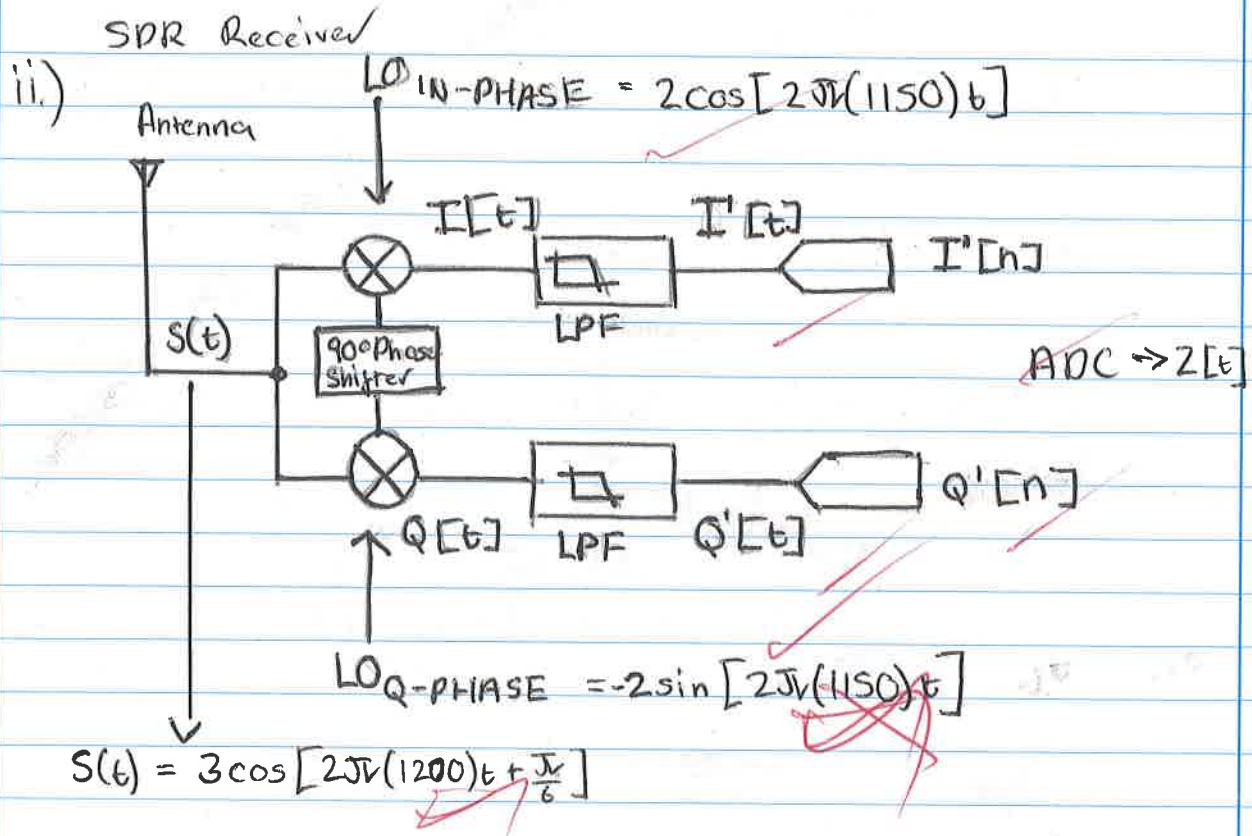
$$\cos A \cdot \sin B = \frac{1}{2} [\sin(A+B) - \sin(A-B)]$$

$$Q(t) = 3 \cdot \frac{1}{2} \left[\cos 2\pi (1200 + 1150)t + \frac{\pi}{6} \right] - \left[\sin 2\pi (1200 - 1150)t \right]$$

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

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

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



iii.) The system converts to the 50 Hz baseband through the subtraction of the frequency component of $S(t)$ (1200 Hz) from the generated LO frequency of 1150 Hz, via $f_m - f_o$, $1200\text{ Hz} - 1150\text{ Hz} = 50\text{ Hz}$.

b.) i.) The frequency generated by the interference in the baseband will be 80 Hz ($1230\text{ Hz} - 1150\text{ Hz}$), so an LPF (Low Pass Filter) with a cut-off frequency of 55-60 Hz could be configured to try and remove this interference as much as possible.

ii.) The interference after will affect the frequency and amplitude of the signal when compared to the signal without interference.

which will not have any distortion in terms of frequency and amplitude. ✓

iii.) A high order filter (low pass) could be used to remove as much of the interference as possible, types such as the Chebyshev or Butterworth. An $n \leq 4$ filter would be effective in removing much of the interference. ✓

$$Q3 = 1+2+2+1+2+4+2+2+1+3 = 20$$

4.)

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

Even = $[1, 3, 4, 2]$ ✓

Odd = $[2, 4, 3, 1]$ ✓

Even :

$x(0) = 1, x(2) = 3, x(4) = 4, x(6) = 2$

Odd

$x(1) = 2, x(3) = 4, x(5) = 3, x(7) = 1$

ii.) $W_N^k = e^{-j \frac{2\pi}{N} k} = \text{Formula}$

$N = 8$

$k = 0, 1, 2, 3$

✓

$$w_8^0 \cancel{x(0)} = e^{-j \frac{2\pi}{8}(1)} = 0.707 - j0.707 ?$$

$$w_8^1 \cancel{x(1)} = e^{-j \frac{2\pi}{8}(2)} = -j ?$$

$$w_8^2 \cancel{x(2)} = e^{-j \frac{2\pi}{8}(3)} = -0.707 - j0.707 ?$$

$$w_8^3 \cancel{x(3)} = e^{-j \frac{2\pi}{8}(4)} = -1 ?$$

iii.) See attached sheet

2.) b.) ii.) $x(n) = \{12.5, 8, 8, 12.5\}$

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

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

$$N = 4$$

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

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

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

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

$$y(n) = \{(0.08 \times 12.5), (0.77 \times 8), (0.77 \times 8), (0.08 \times 12.5)\}$$

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

i.) Ideal FIR filters are not possible as they are finite by nature and cannot have a response to $+\infty$ to $-\infty$. FIR filters may be utilised in wireless communications and sampling.

2.) a.) $x(n) = \begin{cases} \frac{1}{3}, & \text{for } -1 \leq n \leq 1 \\ 0, & \text{otherwise} \end{cases}$

Formula: $x(k) = \sum_{n=0}^{N-1} x(n) e^{-j(2\pi kn/N)}$
 $N=3$

$$x(k) = \sum_{n=0}^2 x(n) e^{-j(2\pi kn/3)}$$

for $n = -1$

$$Q_2 = 2+4+5+1+1 = 13$$

1.) a.) $f(t) = \begin{cases} 1, & \text{for } -2 \leq t \leq -1 \\ 2, & \text{for } -1 \leq t \leq 1 \\ 1, & \text{for } 1 \leq t \leq 2 \\ 0, & \text{otherwise} \end{cases}$ Answer = $F(j\omega) = 2 \cdot \text{sinc}(\omega) + 4 \cdot \text{sinc}(2\omega)$
 c.)

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

Formula:

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

$$F(j\omega) = \int_{-\infty}^{\infty} f(t) e^{-j\omega t} dt$$

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

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

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

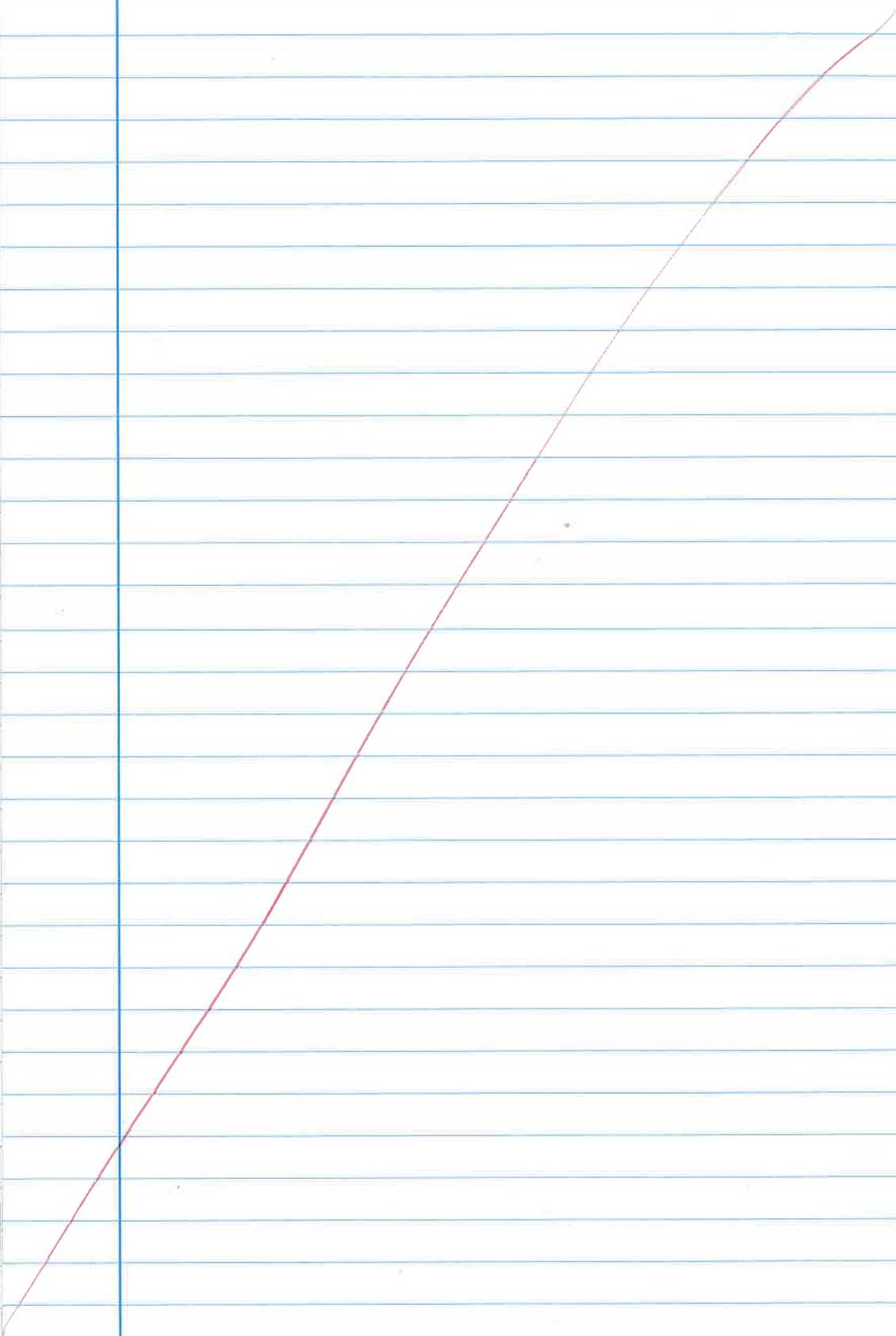
$$\frac{1}{j\omega} [(2e^{-j\omega t} + 2e^{-j\omega t}) + (e^{-j\omega t} + e^{-j\omega t}) + (e^{-j\omega t} + e^{-j\omega t})]$$

$$P_1 = 1 + 2 + 2 + 2 + 2 + 1 = 12$$

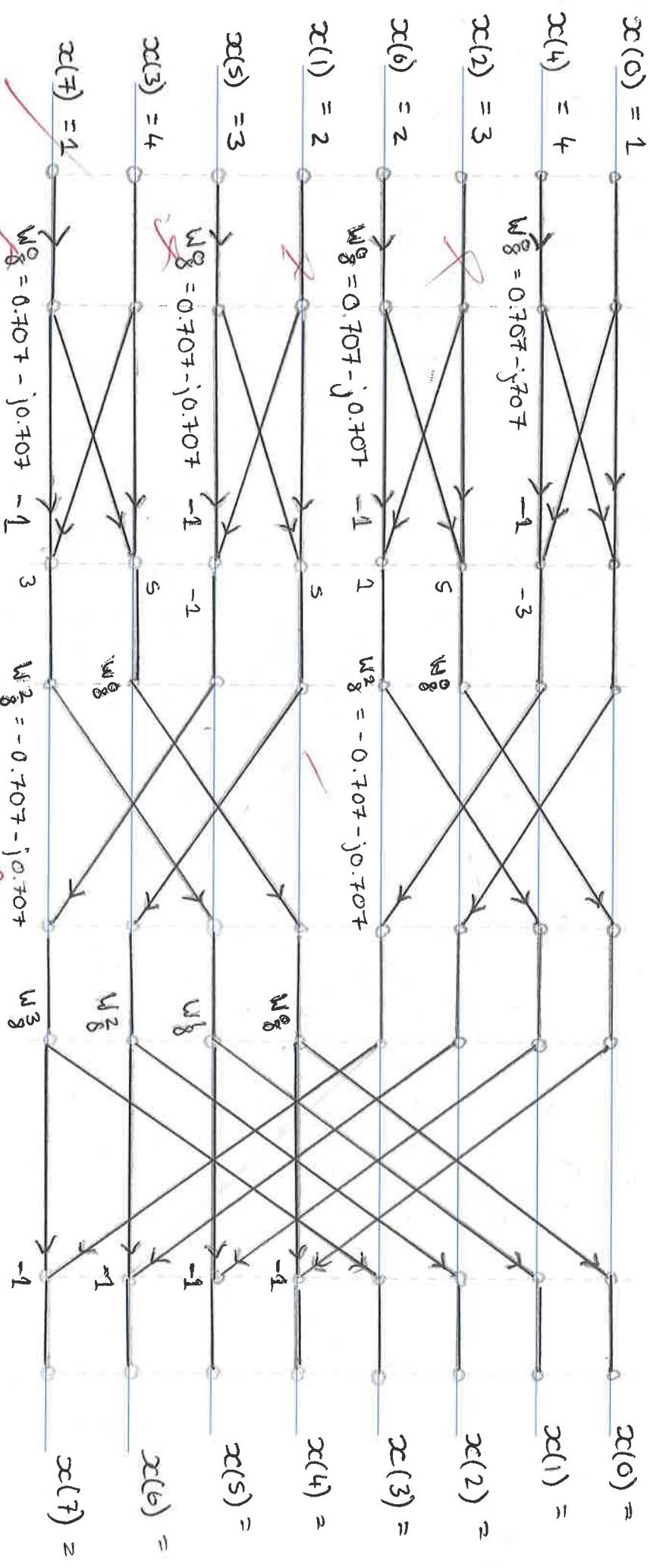


Question No.

Examiner Only



forward = 2



2

$$W_8^4 = -1$$

$$W_8^3 = -1$$