



## 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                   | 2114615                                   |
| 2 | Title of Examination Paper       | Advanced Digital Signal Processing System |
| 3 | Module Code                      | ACDA6018                                  |
| 4 | Date and Time of Examination     | 08/01/25<br>12:00                         |
| 5 | Examination Venue                | 310 (IQ)                                  |
| 6 | Seat Number                      | 058                                       |
| 7 | Number of Answer Books handed in |                                           |

| List the numbers of the questions you have attempted | Office Use |
|------------------------------------------------------|------------|
| Q1                                                   | 21         |
| Q2                                                   | 13         |
| Q3                                                   | 21         |
| Q4                                                   | 25         |
|                                                      |            |
|                                                      |            |
| Q1                                                   | 21         |
| Q2                                                   | 13         |
| Q3                                                   | 21         |
| Q4                                                   | 25         |
|                                                      |            |
|                                                      |            |
|                                                      |            |
|                                                      |            |
| Total                                                | 80/100     |

Q1  
a).

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

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

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

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

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

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

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

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

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

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

Q1

a).

continued.

$$\sin(w) = \frac{e^{jw} - e^{-jw}}{2j}$$

$$F(jw) = \frac{1}{w} [4\sin(w) + 2\sin(2w) - 2\sin(w)]$$

$$F(jw) = \frac{1}{w} [2\sin(w) + 2\sin(2w)]$$

$$F(jw) = \left[ \frac{2\sin(w)}{w} + \frac{2\sin(2w)}{w} \right]$$

$$\text{Sinc}(x) = \frac{\sin(x)}{x}$$

$$F(jw) = \frac{2\sin(w)}{w} + \frac{4\sin(2w)}{2w}$$

$$F(jw) = 2\text{Sinc}(w) + 4\text{Sinc}(2w)$$

Answer C

2

(3)

2

(2)

Q1  
b).

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

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

$$(1) f(t-2) \xleftrightarrow{FT} F(j\omega) e^{-j\omega(2)}$$

$$(2) \cancel{f(t)} \xleftrightarrow{FT} \cancel{F(j\omega)} f(t) e^{-j\omega t} \xleftrightarrow{FT} F(j\omega-1)$$

$$(3) f(f(t-2))e^{j\omega t} \xleftrightarrow{FT} F(\omega-1) e^{-2j(\omega-1)}$$

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

Answer is B

$$Q_1 = 2+3+4+3+2+3+2+2 = 21$$

1-

2-

(3)

2-

(2)

2-  
(2)

21  
25

Q2  
a).

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

(-1, 0, 1)

$$N=3$$

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

$$k=0, 1, 2$$

$$X(k) = \sum_{n=-\infty}^{\infty} x(n) e^{-j\omega n}$$

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

$$X(k) = \left( \frac{1}{5} e^0 \right) + \left( \frac{1}{5} e^{-j\omega(1)} \right) + \left( \frac{1}{5} e^{-j\omega(2)} \right)$$

$$e^0 = 1$$

$$X(k) = \frac{1}{5} + \left( \frac{1}{5} e^{-j\omega} \right) + \left( \frac{1}{5} e^{-2j\omega} \right) \rightarrow \text{Next Page.}$$

$$X(k) = \frac{1}{5} + \left( \frac{1}{5} \frac{e^{-j2\pi(k)}}{3} \right) + \left( \frac{1}{5} \frac{e^{-2j2\pi(k)}}{3} \right)$$

$$X(k) = \frac{1}{5} \left[ \frac{e^{-j2\pi(k)}}{3} + \frac{e^{-2j2\pi(k)}}{3} \right]$$

$$1 + \dots$$

$$k=0$$

$$X(0) = \frac{1}{5} \left[ 1 + \frac{e^{-j2\pi(0)}}{3} + \frac{e^{-2j2\pi(0)}}{3} \right]$$

$$X(0) = \frac{1}{5} + 0 + 0$$

$$X(0) = \frac{1}{5}$$

Q2  
a)  
Continued.

~~$x(1) = \frac{1}{5} \left[ 1 + e^{-j2\pi} \right]$~~

$$x(k) = \frac{1}{5} \left[ 1 + e^{-\frac{j2\pi(k)}{3}} + e^{\frac{j4\pi(k)}{3}} \right] ?$$

$$k=0$$

$$x(0) = \frac{1}{5} + \frac{1}{5} \cdot e^0 + \frac{1}{5} \cdot e^0$$

$$x(0) = \frac{3}{5}$$

$$k=1$$

$$x(1) = \frac{1}{5} + \cancel{\frac{1}{5}} \cdot e^{-\frac{j2\pi}{3}} + \frac{1}{5} \cdot e^{-\frac{j4\pi}{3}}$$

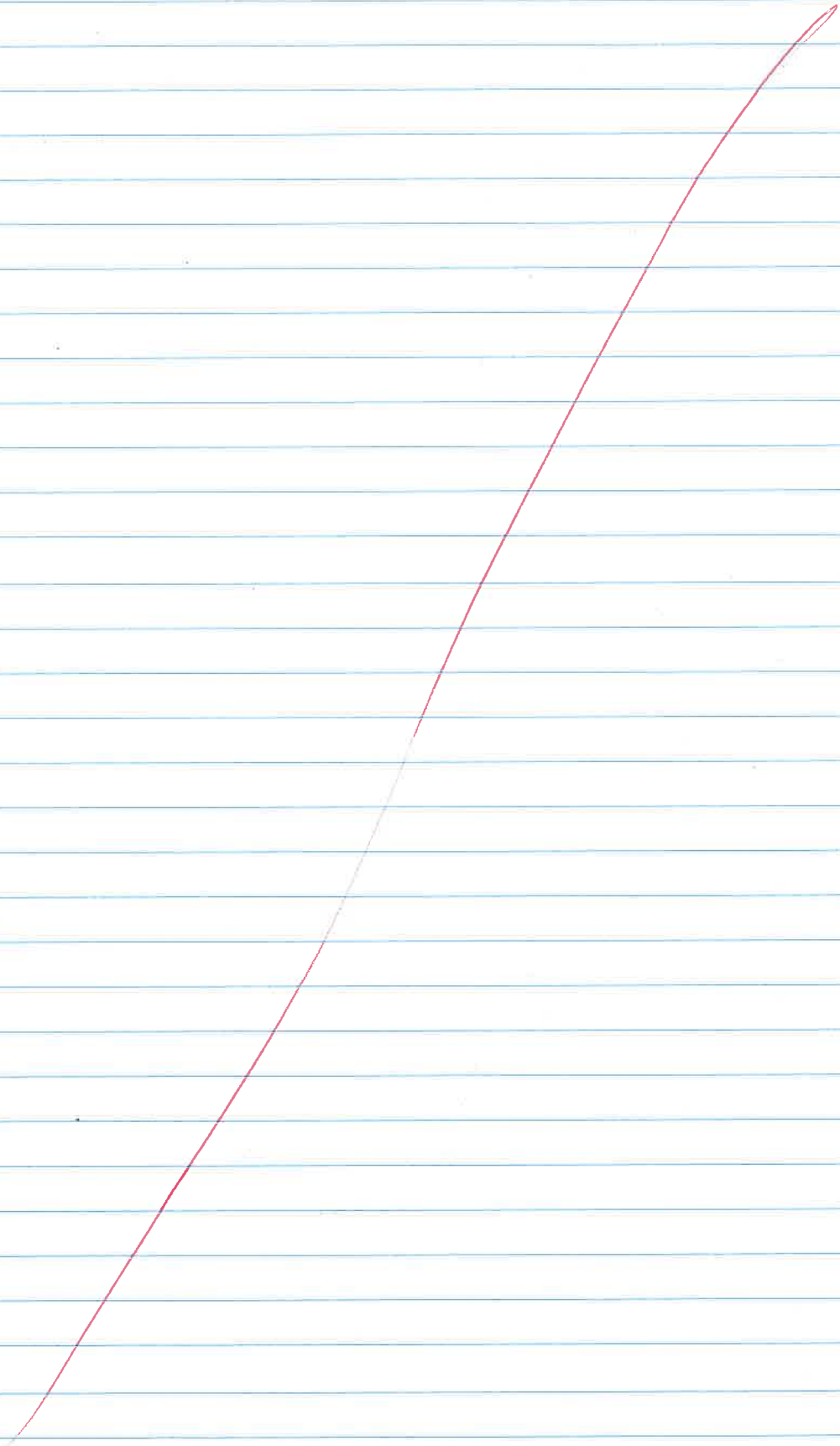
$$q_2 = 1 + 1 + 1 + 1 + 1 = 5 = 13$$

$$\frac{13}{25}$$



Question No.

Examiner Only



Q2

b).

i).

b).

ii).

$$n = (0, 1, 2, 3)$$

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

$$N=4$$

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

$$n=0$$

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

$$W(0) = 0.08$$

$$n=1$$

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

$$W(1) = 0.77$$

$$n=2$$

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

$$W(2) = 0.77$$

$$n=3$$

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

$$W(3) = 0.08$$

1

①

4

④

5

Q2.

b).

ii).

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

$$w(n) = \{0.08, 0.77, 0.77, 0.08\}$$

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

$$n=0$$

$$y(0) = 12.5 \times 0.08$$

$$y(0) = 1$$

$$n=1$$

$$y(1) = 8 \times 0.77$$

$$y(1) = 6.16$$

$$n=2$$

$$y(2) = 8 \times 0.77$$

$$y(2) = 6.16$$

$$n=3$$

$$y(3) = 12.5 \times 0.08$$

$$y(3) = 1$$

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

Q3

a).

i).

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

$$LO_I = 2 \cos(2\pi(1150)t)$$

$$LO_Q = -2 \sin(2\pi(1150)t)$$

$$I(t) = S(t) \cdot LO_I$$

$$Q(t) = S(t) \cdot LO_Q$$

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

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

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

$$Q(t) = \cancel{3 \sin(2\pi(2350)t + \frac{\pi}{6})} = \frac{6}{2}$$

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

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

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

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

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

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

$$Z(t) = 3 e^{j2\pi(50)t + \frac{\pi}{6}}$$

1

1

1

(3)

2

(4)

2

1

1

1

(3)

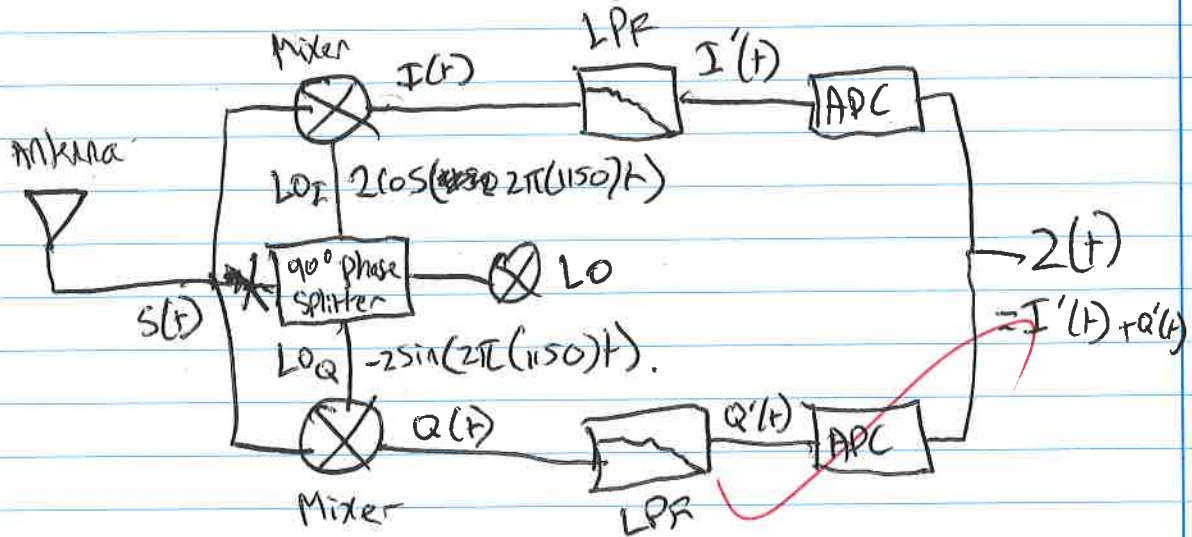
2

(2)

Rhif y Cwestiwn

12

Q3

a.  
n.

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

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

$$I'(t) = 3\cos(2\pi(2350)t + \frac{\pi}{6}) + 3\cos(2\pi(50)t + \frac{\pi}{6})$$

$$Q(t) = 3\sin(2\pi(2350)t + \frac{\pi}{6}) + 3\sin(2\pi(50)t + \frac{\pi}{6})$$

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

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

$$Z'(t) = 3e^{j2\pi(50)t + \frac{\pi}{6}}$$

$$LO_I = 2\cos(2\pi(1150)t)$$

$$LO_Q = -2\sin(2\pi(1150)t)$$

iii). The received signal is mixed with the local oscillator in phase and quadrature phase to achieve  $I(t)$  and  $Q(t)$ . The signals are then passed through a low pass filter to remove the high frequency component and left with the low frequency component.  ~~$2f(t)$~~  or  $I(t)$  and  $Q(t)$  are the baseband components that when added together equals  $2(t)$  which is the baseband representation or I/Q signal.

b).

$$f_{\text{inter}} + f_{\text{rf}} = 2380 \text{ Hz}$$

$$f_{\text{inter}} = f_{\text{rf}} = 80 \text{ Hz}$$

Applying a low pass filter to remove any excess frequency of ~~SSB~~ 60 Hz will remove the interference introduced and retain the signal integrity.

ii). Using <sup>Butter</sup> ~~low pass~~ filters, FIR filters or any other high order filter to remove any excess frequency above 2350 Hz to reduce interference.

$$Q_3 = 3+4+3+2+4+2+3 = 21$$

$$\frac{21}{25}$$

Q4

a

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

$$\begin{aligned} \text{even } \{1, 3, 4, 2\} & \quad \text{even } \{1, 4\} \\ \text{odd } \{2, 4, 3, 1\} & \quad \text{odd } \{3, 2\} \\ & \quad \text{even } \{2, 3\} \\ & \quad \text{odd } \{4, 1\} \end{aligned}$$

$$N=8$$

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

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

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

$$\begin{aligned} W_8^2 &= e^{-j\frac{2\pi}{8}2} \\ &= -1 \end{aligned}$$

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

$$= -0.707 - j0.707$$

$$Q_4 = 2+2+2+2 = 25$$

25

25

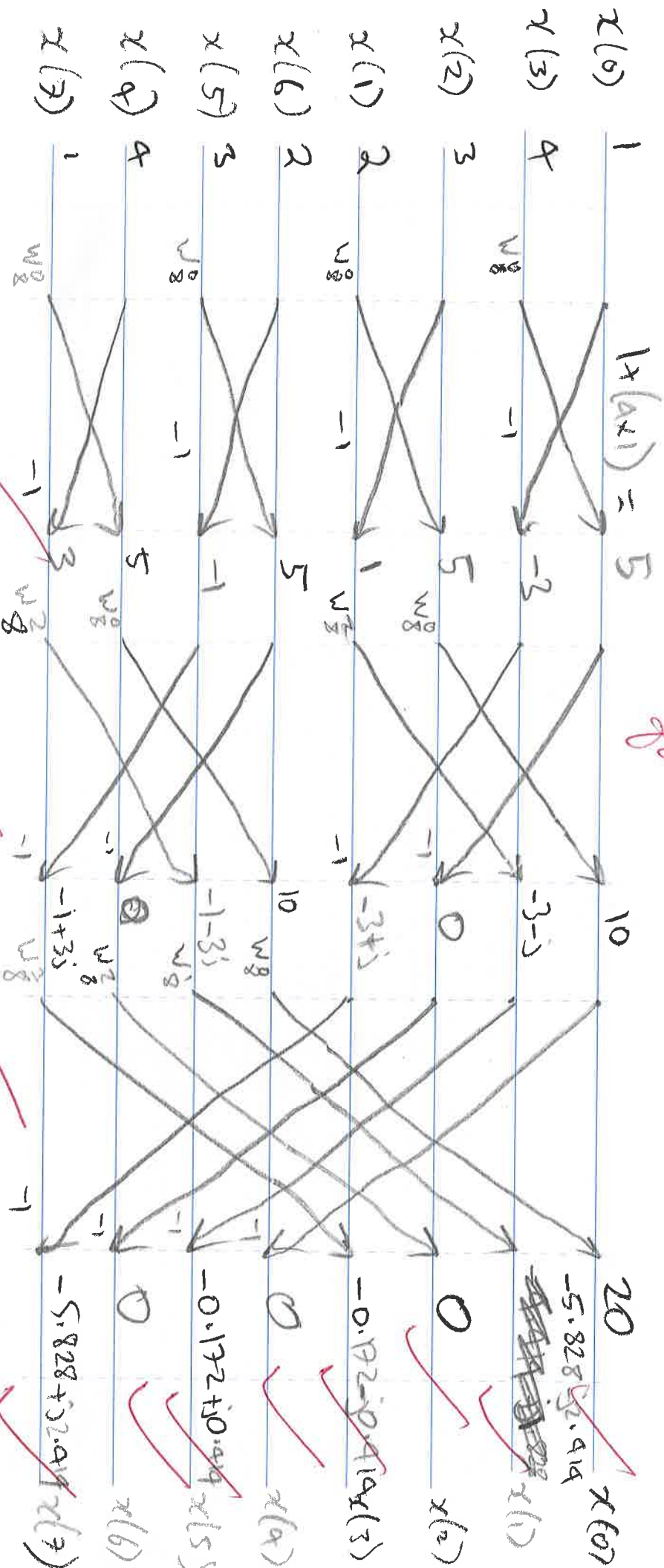
Q4 D.

Stage 1  
(k=0)

Stage 2  
(k=0,2)

Stage 3  
(k=0,1,2,3)

forward



$$W_8^0 = 1$$

$$W_8^1 = 0.707 - j0.707$$

$$W_8^2 = -j$$

$$W_8^3 = -0.707 - j0.707$$

①

①

①

②

⑩