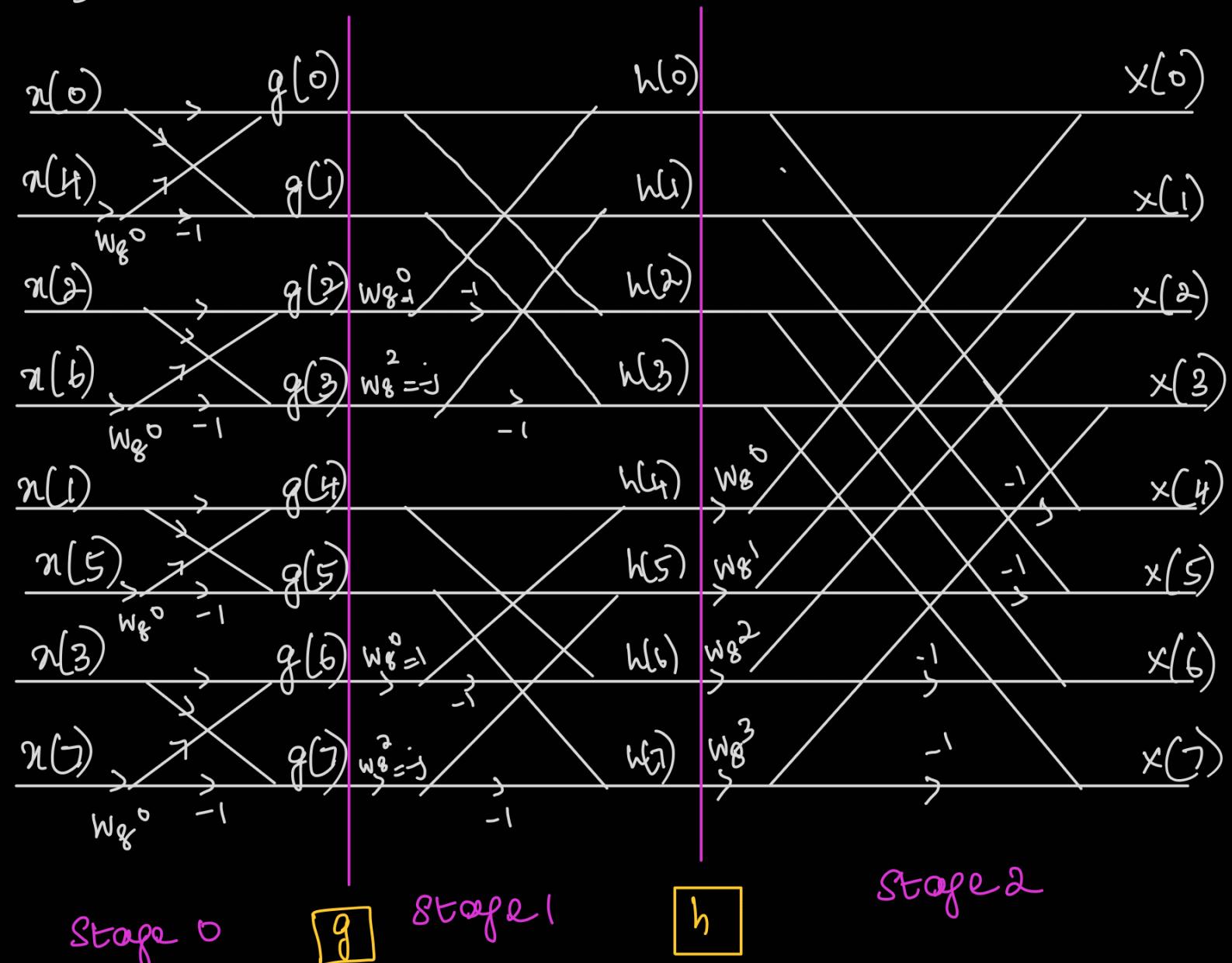


## Example i/p

$$\begin{aligned}x_0 &= 0 \cdot 0 + j 0 \cdot 0 \\x_1 &= 1 \cdot 0 + j 0 \cdot 0 \\x_2 &= 2 \cdot 0 + j 0 \cdot 0 \\x_3 &= 3 \cdot 0 + j 0 \cdot 0\end{aligned}$$

$$\begin{aligned}x_4 &= 4 \cdot 0 + j 0 \cdot 0 \\x_5 &= 5 \cdot 0 + j 0 \cdot 0 \\x_6 &= 6 \cdot 0 + j 0 \cdot 0 \\x_7 &= 7 \cdot 0 + j 0 \cdot 0\end{aligned}$$



$$w_N^n = \left( e^{-j \frac{2\pi n}{N}} \right)^n ; \quad w_8 = e^{\frac{-j 2\pi n}{8}} = e^{\frac{-j n\pi}{4}}$$

$g \Rightarrow$  o/p of stage 0 calculations

$h \Rightarrow$  o/p of stage 1 calculations

## Stage 1 Calculations :

$$g(0) = n(0) + n(4) = (0 \cdot 0 + j0 \cdot 0) + (4 \cdot 0 + j0 \cdot 0) = 4 \cdot 0 + j0 \cdot 0$$

$$g(1) = n(0) - n(4) = (0 \cdot 0 + j0 \cdot 0) - (4 \cdot 0 + j0 \cdot 0) = -4 \cdot 0 + j0 \cdot 0$$

$$g(2) = n(2) + n(6) = (2 \cdot 0 + j0 \cdot 0) + (6 \cdot 0 + j0 \cdot 0) = 8 \cdot 0 + j0 \cdot 0$$

$$g(3) = n(2) - n(6) = (2 \cdot 0 + j0 \cdot 0) - (6 \cdot 0 + j0 \cdot 0) = -4 \cdot 0 + j0 \cdot 0$$

$$g(4) = n(1) + n(5) = (1 \cdot 0 + j0 \cdot 0) + (5 \cdot 0 + j0 \cdot 0) = 6 \cdot 0 + j0 \cdot 0$$

$$g(5) = n(1) - n(5) = (1 \cdot 0 + j0 \cdot 0) - (5 \cdot 0 + j0 \cdot 0) = -4 \cdot 0 + j0 \cdot 0$$

$$g(6) = n(3) + n(7) = (3 \cdot 0 + j0 \cdot 0) + (7 \cdot 0 + j0 \cdot 0) = 10 \cdot 0 + j0 \cdot 0$$

$$g(7) = n(3) - n(7) = (3 \cdot 0 + j0 \cdot 0) - (7 \cdot 0 + j0 \cdot 0) = -4 \cdot 0 + j0 \cdot 0$$

$$\frac{n(0)}{\hookrightarrow} \text{in}_0\text{-real}[15:0], \quad \text{in}_0\text{-imag}[15:0]$$

$$\frac{n(4)}{\hookrightarrow} \text{in}_4\text{-real}[15:0], \quad \text{in}_4\text{-imag}[15:0]$$

$$g(0) = n(0) + n(4)$$

$$g_0\text{-real}[15:0] = \text{in}_0\text{-real}[15:0] + \text{in}_4\text{-real}[15:0]$$

$$g_0\text{-imag}[15:0] = \text{in}_0\text{-imag}[15:0] + \text{in}_4\text{-imag}[15:0]$$

## Stage 2 Calculations :

$$h(0) = g(0) + g(2)$$

$$h(1) = g(1) - j \cancel{g(3)}$$

$$h(2) = g(0) - g(2)$$

$$h(3) = g(1) + j g(3)$$

$$h(4) = g(4) + g(6)$$

$$h(5) = g(5) - j g(7)$$

$$h(6) = g(4) - g(6)$$

$$h(7) = g(5) + j g(7)$$

$$\begin{aligned} h(0) &= g(0) + g(2) \\ &= (4 \cdot 0 + j 0 \cdot 0) + (8 \cdot 0 + j 0 \cdot 0) \\ h(0) &= 12 \cdot 0 + j 0 \cdot 0 \end{aligned}$$

$$h(1) = g(1) - j g(3) = g(1) - g'(3)$$

$$\begin{aligned} g'(3) = j g(3) &= j(g(3)_{\text{real}} + j g(3)_{\text{imag}}) \\ &= j g(3)_{\text{real}} - g(3)_{\text{imag}} \end{aligned}$$

$$g'(3) = -g(3)_{\text{imag}} + j g(3)_{\text{real}}$$

$$\Rightarrow \begin{cases} g'(3)_{\text{real}} = -g(3)_{\text{imag}} \\ g'(3)_{\text{imag}} = g(3)_{\text{real}} \end{cases}$$

$$h(1) = \begin{pmatrix} -4+j0.0 \\ -4+j0.0 \end{pmatrix} - j \begin{pmatrix} -4+j0.0 \\ +j4+0.0 \end{pmatrix}$$

$$h(1) = -4+j4$$

$$h(2) = g(0) - g(2) = \begin{pmatrix} 4 \cdot 0 + j0 \cdot 0 \\ 8 \cdot 0 + j0 \cdot 0 \end{pmatrix} - \begin{pmatrix} 8 \cdot 0 + j0 \cdot 0 \\ -4 \cdot 0 + j0 \cdot 0 \end{pmatrix} = -4 \cdot 0 + j0 \cdot 0$$

$$h(3) = g(1) + j g'(3) = g(1) + g'(3)$$

$$g'(3) = j(g(3)-\text{real} + j g(3)-\text{imag})$$

$$= -g(3)-\text{imag} + j g(3)-\text{real}$$

$$\Rightarrow \begin{cases} g'(3)-\text{real} = -g(3)-\text{imag} \\ g'(3)-\text{imag} = g(3)-\text{real} \end{cases}$$

$$h(3) = \begin{pmatrix} 4 \cdot 0 + j0 \cdot 0 \\ -4 \cdot 0 + j0 \cdot 0 \end{pmatrix} + j \begin{pmatrix} -4 \cdot 0 + j0 \cdot 0 \\ -j4 \cdot 0 - 0 \cdot 0 \end{pmatrix}$$

$$= \begin{pmatrix} -4 \cdot 0 + j0 \cdot 0 \\ -4 \cdot 0 - j4 \cdot 0 \end{pmatrix}$$

$$h_3 = -4 \cdot 0 - j4 \cdot 0$$

$$h(4) = g(4) + g(6)$$

$$= \begin{pmatrix} 6+j0 \cdot 0 \\ 10+j0 \cdot 0 \end{pmatrix} = \begin{pmatrix} 16 \cdot 0 + j0 \cdot 0 \\ 10+j0 \cdot 0 \end{pmatrix}$$

$$h(4) = 16 \cdot 0 + j0 \cdot 0$$

$$h(5) = g(5) - j g'(5) = g(5) - g''(5)$$

$$g'(5) = j(g(5)-\text{real} + j g(5)-\text{imag})$$

$$= j g(5)-\text{real} - g(5)-\text{imag}$$

$$\Rightarrow \boxed{g'(5)-\text{real} = -g(5)-\text{imag}}$$

$$g'(5)-\text{imag} = g(5)-\text{real}$$

$$h(5) = g(5) - j g'(5) = (-4+j0) - j(-4+j0-0)$$

$$= -4+j0 + j4 - 0$$

$$h(5) = -4+j4$$

$$h(6) = g(6) - g'(6) = (6+j0-0) - (10-0+j0-0)$$

$$h(6) = -4-0 + j0-0$$

$$h(5) = g(5) + j g'(5) = g(5) + g''(5)$$

$$g''(5) = j g'(5) = j(g(5)-\text{real} + j g(5)-\text{imag})$$

$$= j g(5)-\text{real} - g(5)-\text{imag}$$

$$g''(5)-\text{real} = -g(5)-\text{imag}$$

$$g''(5)-\text{imag} = g(5)-\text{real}$$

$$h(7) = g(5) + jg(7) = (-4+j0 \cdot 0) + j(-4 \cdot 0 + j0 \cdot 0)$$

$$= -4 + j0 \cdot 0 - j4 \cdot 0 + 0$$

$$h(7) = -4 - j4$$

Stage 2 Results :

$$h(0) = 12 \cdot 0 + j0 \cdot 0$$

$$h(1) = -4 \cdot 0 + 4 \cdot 0$$

$$h(2) = -4 \cdot 0 + j0 \cdot 0$$

$$h(3) = -4 \cdot 0 - j4 \cdot 0$$

$$h(4) = 16 \cdot 0 + j0 \cdot 0$$

$$h(5) = -4 \cdot 0 + j4 \cdot 0$$

$$h(6) = -4 \cdot 0 + j0 \cdot 0$$

$$h(7) = -4 - j4$$

$$w_8^0 = 1;$$

$$w_8^1 = e^{-j\frac{2\pi}{8}} = e^{-j\frac{\pi}{4}} = \cos \frac{\pi}{4} - j \sin \frac{\pi}{4} = \left(\frac{1}{\sqrt{2}} - \frac{j}{\sqrt{2}}\right)$$

$$w_8^2 = e^{-j\frac{2\pi}{8} \times 2} = e^{-j\frac{\pi}{2}} = -j$$

$$w_8^3 = \left(e^{-j\frac{2\pi}{8}}\right)^3 = e^{-j\frac{6\pi}{8}} = -\frac{1}{\sqrt{2}} - \frac{j}{\sqrt{2}} = -\frac{(1+j)}{\sqrt{2}}$$

### Stage 3 Computations :

$i[ ] \rightarrow$  wires to denote o/p of stage 3.

$$i[0] = h(0) + h(4)$$

$$i[0] = (12 \cdot 0 + j0 \cdot 0) + (16 \cdot 0 + j0 \cdot 0) = 28 \cdot 0 + j0 \cdot 0$$

$$i[1] = h(1) + W_8^1 h(5)$$

$$= (-4 + j4 \cdot 0) + (-4 + j4 \cdot 0) \left( \frac{1-j}{\sqrt{2}} \right)$$

$$= (-4 + j4) + (-4 + j4)(0 \cdot 707 - j0 \cdot 707)$$

$$= -4 + j4 - 2 \cdot 828 + j2 \cdot 828 + 2 \cdot 828$$

$$= (-4 - 2 \cdot 828 + 2 \cdot 828) + j(4 + 2 \cdot 828 + 2 \cdot 828)$$

$$i[1] = -4 + j(9 \cdot 656)$$

$$i[2] = h[2] + W_8^2 h(6) = h[2] - j h[6]$$

$$= (-4 + j0) + -j(-4 + j0 \cdot 0)$$

$$i[2] = -4 + j0 \cdot 0 + j4 = -4 + j4$$

$$i[2] = h[2] - h'[6]$$

$$h'[6] = j h[6] = j [h[6]_{\text{real}} + j h[6]_{\text{imag}}]$$

$$= j h[6]_{\text{real}} - h[6]_{\text{imag}}$$

$$\begin{aligned} h'[6]_{\text{real}} &= -h[6]_{\text{imag}} \\ h'[6]_{\text{imag}} &= h[6]_{\text{real}} \end{aligned}$$

$i[3]$  → to be implemented

$$\begin{aligned} i[4] &= h[0] - h[4] \\ &= (12 \cdot 0 + j 0 \cdot 0) - (16 \cdot 0 + j 0 \cdot 0) \\ i[4] &= -16 \cdot 0 + j 0 \cdot 0 \end{aligned}$$

$i[5]$  = to be implemented later

$$\begin{aligned} i[6] &= h[2] - w_8^2 h[6] \\ &= h[2] - (-j) h[6] = h[2] + j h[6] \\ &= h[2] + h'[6] \\ h'[6] &= j (h[6]_{\text{real}} + j h[6]_{\text{imag}}) \\ &= j h[6]_{\text{real}} - h[6]_{\text{imag}} \end{aligned}$$

$$\begin{aligned} h'[6]_{\text{real}} &= -h[6]_{\text{imag}} \\ h'[6]_{\text{imag}} &= h[6]_{\text{real}} \end{aligned}$$

$$i[6] = (-16 \cdot 0 + j 0 \cdot 0) + j (-16 \cdot 0 + j 0 \cdot 0)$$

$$i[6] = -4.0 - j4.0$$

$$i(1) =$$