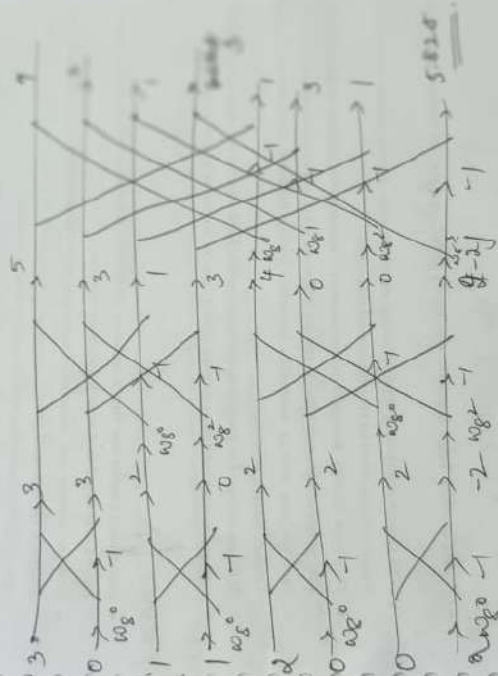
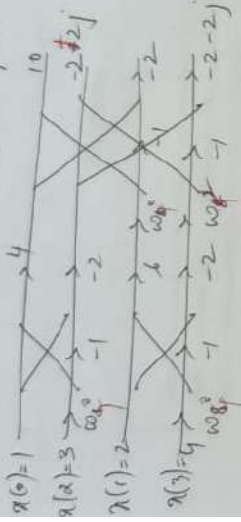


② $x(n) = \{1, 2, 3, 2, 1, 0\}$ $x(0)=3, x(1)=2, x(2)=1$
 $x(3)=0, x(4)=0, x(5)=0$
 $x(6) = x(n-N) = x(6-8) = x(-2) = 1$
 $x(7) = x(n-N) = x(7-8) = x(-1) = 2$

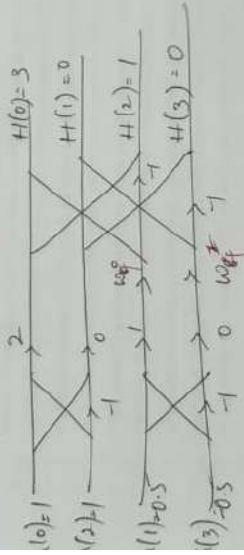


$$\begin{aligned}
 3 + w_8^3(2-2j) &= 3 + (10.707 - 0.707j)(2-2j) \\
 &= 3 + 1.414 - 1.414j + 1.414j - 1.414j^2 \\
 &= 3 - (-1.414 - 1.414j) + 1.414j + 1.414j^2 \\
 &= 3 + 1.414 + 1.414j - 1.414j + 1.414j^2 \\
 &= 5.828
 \end{aligned}$$

③ $x(n) = \{1, 2, 3, 4\}$ $h(n) = \{1, 0.5, 1, 0.5\}$



$4 - 6$
 $-2 - 4j(-2)$
 $-2 + 2 \cdot 4j$
 $-2 - 2j$
 $N/4 = -j$

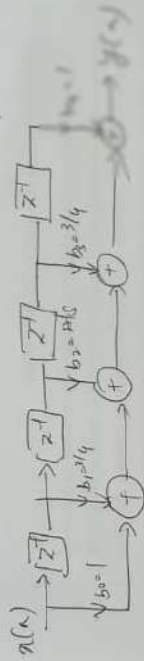


$Y(0) = X(0) \cdot H(0) = 10 \cdot 3 = 30$
 $Y(1) = X(1) \cdot H(1) = (-2+2j) \cdot 0 = 0$
 $Y(2) = X(2) \cdot H(2) = (-2) \cdot 1 = -2$
 $Y(3) = X(3) \cdot H(3) = (-2-2j) \cdot 0 = 0$

$Y(k) = \{30, 0, -2, 0\}$

Realize $1 + \frac{3}{4}z^{-1} + \frac{17}{8}z^{-2} + \frac{3}{4}z^{-3} + z^{-4}$
in direct form.

$$b_0 = 1, \quad b_1 = 3/4, \quad b_2 = 17/8, \quad b_3 = 3/4, \quad b_4 = 1$$



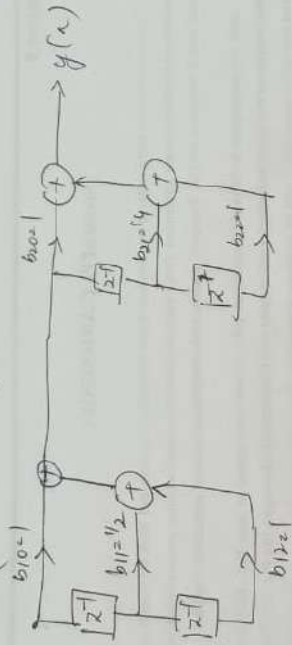
Cascaded form

$$\begin{aligned}
 H(z) &= H_1(z) \cdot H_2(z) \\
 &= (b_{10} + b_{11}z^{-1} + b_{12}z^{-2}) (b_{20} + b_{21}z^{-1} + b_{22}z^{-2}) \\
 &= b_{10}b_{20} + b_{11}b_{20}z^{-1} + b_{12}b_{20}z^{-2} + b_{21}b_{10}z^{-1} + \\
 &\quad b_{11}b_{21}z^{-2} + b_{12}b_{21}z^{-3} + b_{22}b_{10}z^{-2} + b_{11}b_{22}z^{-3} + \\
 &\quad b_{12}b_{22}z^{-4} \\
 &= b_{10}b_{20} + (b_{11}b_{20} + b_{21}b_{10})z^{-1} + (b_{12}b_{20} + b_{11}b_{21} + \\
 &\quad + b_{22}b_{10})z^{-2} + (b_{12}b_{21} + b_{11}b_{22})z^{-3} + b_{12}b_{22}z^{-4}
 \end{aligned}$$

$$\begin{aligned}
 b_{10}b_{20} &= 1 \\
 b_{11}b_{20} + b_{21}b_{10} &= 3/4 \\
 b_{12}b_{20} + b_{11}b_{21} + b_{22}b_{10} &= 17/8 \\
 b_{12}b_{21} + b_{11}b_{22} &= 3/4 \\
 b_{12}b_{22} &= 1
 \end{aligned}$$

$$\begin{aligned}
 b_{10} &= 1, \quad b_{11} = 1/2, \quad b_{12} = 1, \quad b_{20} = 1, \quad b_{21} = 1/4, \quad b_{22} = 1.
 \end{aligned}$$

$$H_1(z) = (1 + \frac{1}{2}z^{-1} + z^{-2}) \quad H_2(z) = 1 + \frac{1}{4}z^{-1} + z^{-2}$$



$$H_d(\omega) = \begin{cases} 1 & \text{for } |\omega| \leq \pi/6 \\ 0 & \text{for } \pi/6 < |\omega| \leq \pi \end{cases}$$

$$h_d(n) = \frac{1}{2\pi} \int_{-\pi/6}^{\pi/6} 1 \cdot e^{jn\omega} d\omega$$

$$= \frac{1}{2\pi} \int_{-\pi/6}^{\pi/6} e^{jn\omega} d\omega, \quad n \neq 0$$

$$\text{For } n=2 \quad \frac{1}{2\pi} \int_{-\pi/6}^{\pi/6} e^{j2\omega} d\omega = \frac{1}{2\pi} \left[\frac{e^{j2\omega}}{2} \right]_{-\pi/6}^{\pi/6}$$

The impulse response of the filter

$$h(n) = \begin{cases} \frac{1}{2\pi} \int_{-\pi/6}^{\pi/6} e^{jn\omega} d\omega & n \neq 0 \\ 1 & n = 0 \end{cases}$$

$$h(n) = \begin{cases} \frac{1}{2\pi} \int_{-\pi/6}^{\pi/6} e^{jn\omega} d\omega & n \neq 0 \\ 1 & n = 0 \end{cases}$$

$$hd(n) = h_{\text{Hann}}(n) \quad h(n) = hd(n) \cdot h_{\text{Hann}}(n)$$

$$(e^{j\omega}) = e^{-j\omega \left(\frac{N-1}{2}\right)} h\left(\frac{N-1}{2}\right) + \sum_{n=2}^{N-3} 2h(n)$$

$$\cos \left[\omega \left(n - \left(\frac{N-1}{2} \right) \right) \right]$$

$$= e^{-j2\omega} h(2) + 2h(0) \cos 2\omega + 2h(1) \cos 2\omega$$

$$hd(n) = \begin{cases} 1 & \pi/4 \leq \omega < 3\pi/4 \\ 0 & \end{cases}$$

$$\omega_{c1} = \pi/4 \quad \omega_{c2} = 3\pi/4$$

$$hd(n) = \begin{cases} \frac{\sin \omega_{c2}(n-z) - \sin \omega_{c1}(n-z)}{n-z} & \text{for } n \neq z \\ \frac{\omega_{c2} - \omega_{c1}}{\pi} & \text{for } n = z \end{cases}$$

$$z = \frac{N-1}{2} = \frac{11-1}{2} = 5$$

$$hd(n) = \begin{cases} \frac{2}{\pi} \sin \left(\frac{3\pi(n-5)}{4} \right) - \sin \left(\frac{\pi(n-5)}{4} \right) & \text{for } n \neq 5 \end{cases}$$

$$\frac{\sin \frac{\pi}{4} - \pi/4}{\pi} = 1/5 \quad \text{for } n=5$$

To obtain $h(n)$ by windowing technique

$$h(n) = hd(n) \quad \text{for } 0 \leq n \leq n-1$$

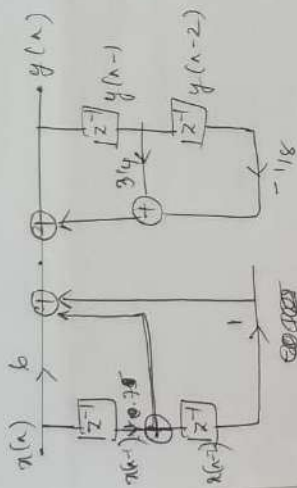
$$h(n) = hd(n) \quad \text{for } 0 \leq n \leq 10$$

n	hd(n)	wp(n)	h(n)
0	0	1	0
1	0	1	0
2	0	1	0
3	-0.3183	1	-0.3183
4	0	1	0
5	1/5	1	1/5
6	0	1	0
7	-0.3183	1	-0.3183
8	0	1	0
9	0	1	0
10	0	1	0

8) $y(n] = 0.75y(n-1) - 0.125y(n-2) + 6x(n) + 7x(n-1) + 2x(n-2)$

$y(n] = 0.75y(n-1) - 0.125y(n-2) + 6x(n) + 7x(n-1) + 2x(n-2)$

Direct form I structure



Direct form II structure

