SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF BIOMEDICAL ENGINEERING

19BMB302 - BIOMEDICAL SIGNAL PROCESSING

III YEAR/ V SEMESTER

UNIT II FINITE IMPULSE RESPONSE FILTERS

- Introduction to FIR
- Linear phase FIR filter
- FIR filter design using window method
- Low Pass Filter
- Frequency sampling method
- Realization of FIR filter using direct form 1, Direct form 2
- Realization of FIR filter using Cascade structures
- Realization of FIR filter using parallel structures

Example 6.22 Determine the direct form realization of system function $H(z) = 1 + 2z^{-1} - 3z^{-2} - 4z^{-3} + 5z^{-4}$.

Solution Given $H(z) = 1 + 2z^{-1} - 3z^{-2} - 4z^{-3} + 5z^{-4}$

$$Y(z) = X(z) + 2z^{-1}X(z) - 3z^{-2}X(z) - 4z^{-3}X(z) + 5z^{-4}X(z) \quad (6.160)$$

The above equation can be realized as shown in Fig. 6.71.

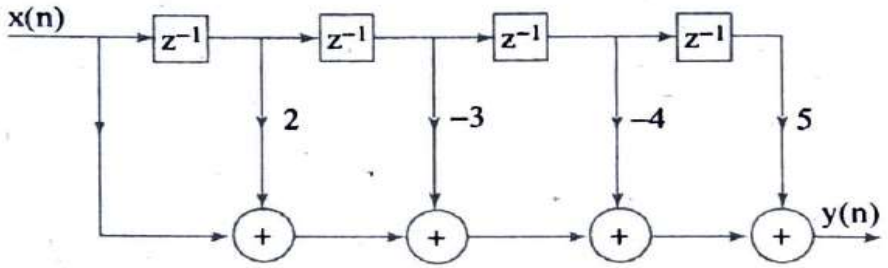


Fig. 6.71 Realization structure of example 6.22

Example 6.23 Obtain the cascade realization of system function $H(z) = (1 + 2z^{-1} - z^{-2})(1 + z^{-1} - z^{-2})$.

Solution

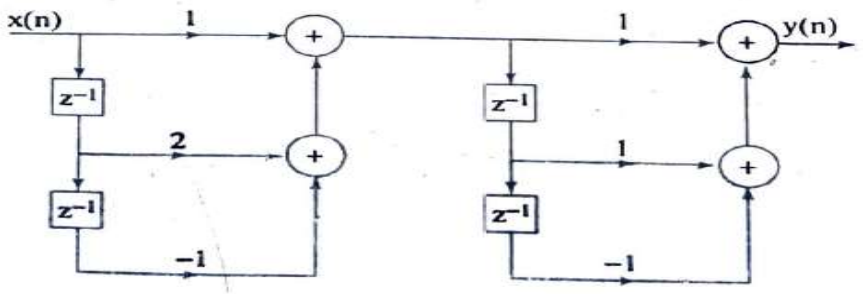
$$H(z) = H_1(z)H_2(z)$$

where $H_1(z) = 1 + 2z^{-1} - z^{-2}$ and $H_2(z) = 1 + z^{-1} - z^{-2}$

$$H_1(z) = \frac{Y_1(z)}{X_1(z)} \Rightarrow Y_1(z) = X_1(z) + 2z^{-1}X_1(z) - z^{-2}X(z) \qquad (6.161)$$

$$H_2(z) = \frac{Y_2(z)}{X_2(z)} \Rightarrow Y_2(z) = X_2(z) + z^{-1}X_2(z) - z^{-2}X(z) \qquad (6.162)$$

The Eq. (6.161) and Eq. (6.162) can be realized in direct form and can be cascaded as shown in the Fig. 6.72.



Example 6.24 Obtain the cascade realization of system function

$$H(z) = 1 + \frac{5}{2}z^{-1} + 2z^{-2} + 2z^{-3}$$

Solution Given

$$\begin{aligned} H(z) &= 1 + \frac{5}{2}z^{-1} + 2z^{-2} + 2z^{-3} \\ &= (1 + 2z^{-1})\left(1 + \frac{1}{2}z^{-1} + z^{-2}\right) \end{aligned} \tag{6.163}$$

The above Eq. (6.163) can be realized in cascade form as shown in Fig. 6.73.

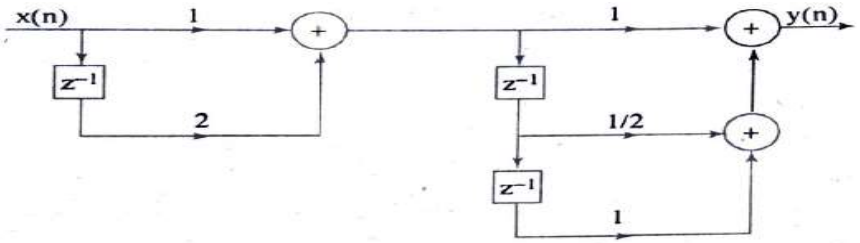


Fig. 6.73 Cascade realization of example 6.24

6.11.2 *Linear Phase Realization*

For a linear phase FIR filter

$$h(n) = h(N-1-n)$$

$$H(z) = \sum_{n=0}^{N-1} h(n) z^{-n}$$

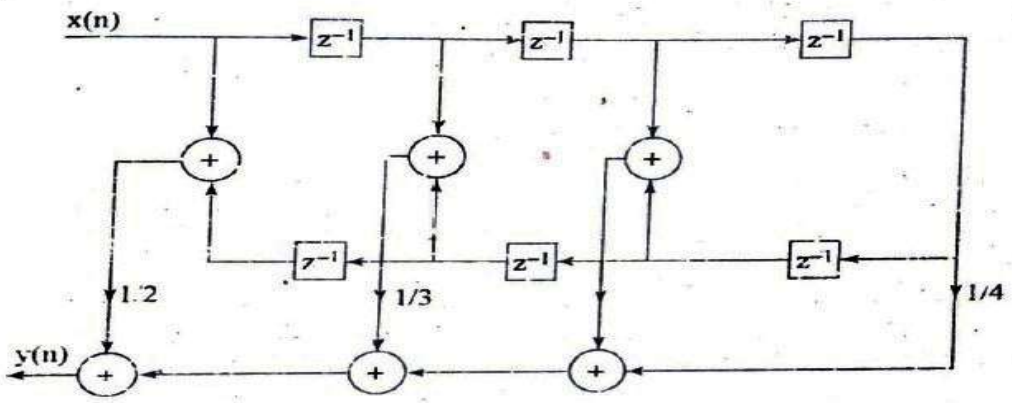
Example 6.25 Realize the system function

$$H(z) = \frac{1}{2} + \frac{1}{3}z^{-1} + z^{-2} + \frac{1}{4}z^{-3} + z^{-4} + \frac{1}{3}z^{-5} + \frac{1}{2}z^{-6}$$

Solution By inspection we find that the system function $H(z)$ is that of a linear phase FIR filter and

$$h(n) = h(N-1-n).$$

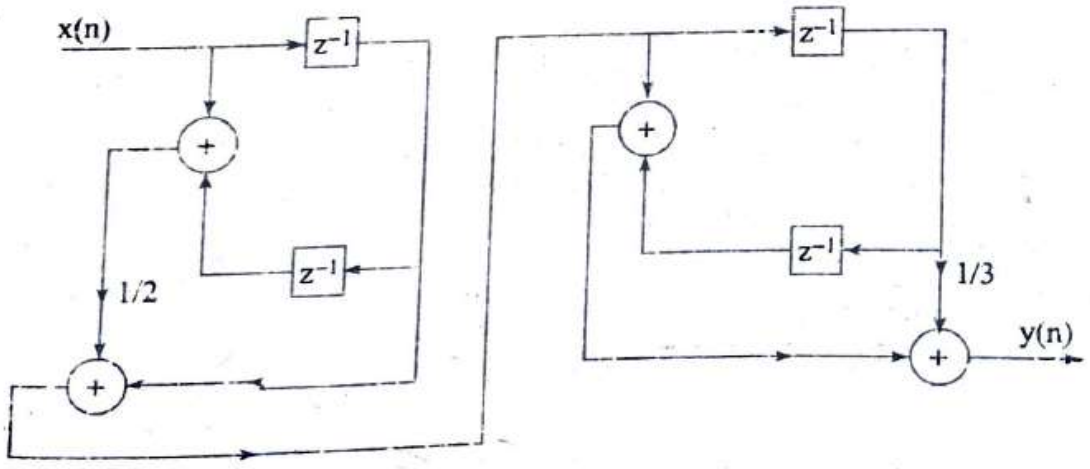
Therefore, we can realize the system function as shown in Fig. 6.75.



Example 6.26 Obtain cascade realization with minimum number of multipliers for the system function

$$H(z) = \left(\frac{1}{2} + z^{-1} + \frac{1}{2}z^{-2}\right)\left(1 + \frac{1}{3}z^{-1} + z^{-2}\right)$$

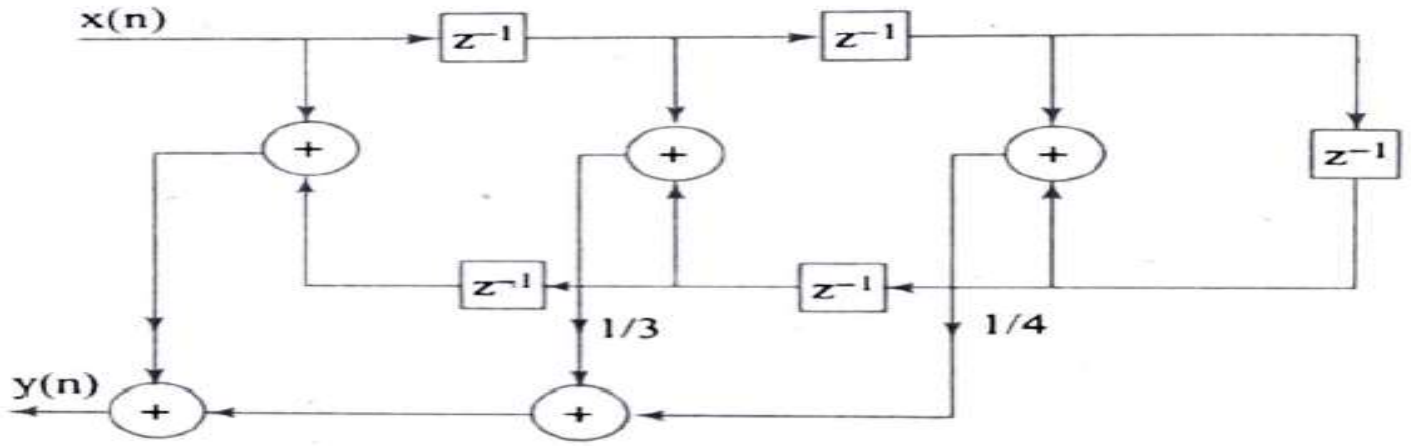
Solution



Example 6.27 Realize the following system function using minimum no. of multipliers

(i) $H(z) = 1 + \frac{1}{3}z^{-1} + \frac{1}{4}z^{-2} + \frac{1}{4}z^{-3} + \frac{1}{3}z^{-4} + z^{-5}$

(ii) $H(z) = (1 + z^{-1})\left(1 + \frac{1}{2}z^{-1} + \frac{1}{2}z^{-2} + z^{-3}\right)$



Example 6.27 Realize the following system function using minimum no. of multipliers

(ii) $H(z) = (1 + z^{-1})\left(1 + \frac{1}{2}z^{-1} + \frac{1}{2}z^{-2} + z^{-3}\right)$