AL- MUSTAQBAL UNIVERSITY COLLEGE
DEPARTMENT OF BIOMEDICAL ENGINEERING

Signals and Systems for BME

BME 322

Lecture 8

- Direct-form structures -

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Direct-form FIR structures

- FIR filters of order M is characterized by M + 1 coefficients which require M + 1 multipliers, and M two-input adder.

- For FIR filters in which the multiplier coefficients are precisely the coefficients of the transfers function are called direct-form structures

Direct-form FIR structures

- FIR filters transfer function:

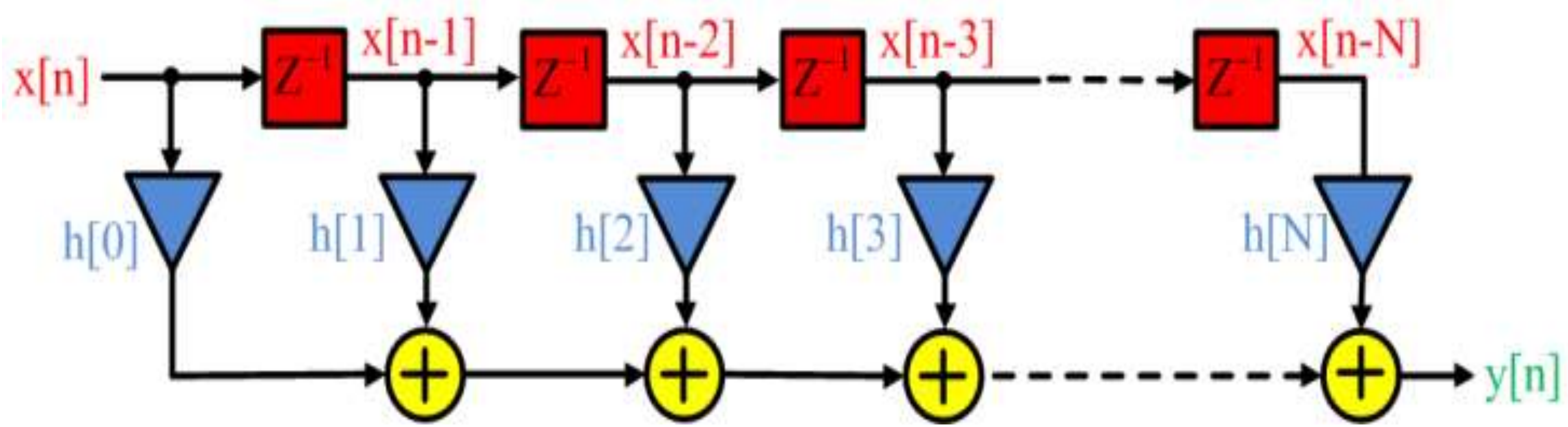
$$H[z] = \frac{y[z]}{x[z]} = \sum_{K=0}^{M} h_k \, z^{-k}$$

- Which is a polynomial in z^{-1} of degree M.

Direct-form FIR structures

- Expanding the filters transfer function:

$$y[n] = h[0]x[n] + h[1]x[n-1] + h[2]x[n-2] + h[3]x[n-3] + \ldots + h[N]x[n-N]$$



Example

Based on the transfer function, realize the digital filter using the direct form.

$$H(z) = (1-2z^{-1})(1+ z^{-1}-4\, z^{-2})$$

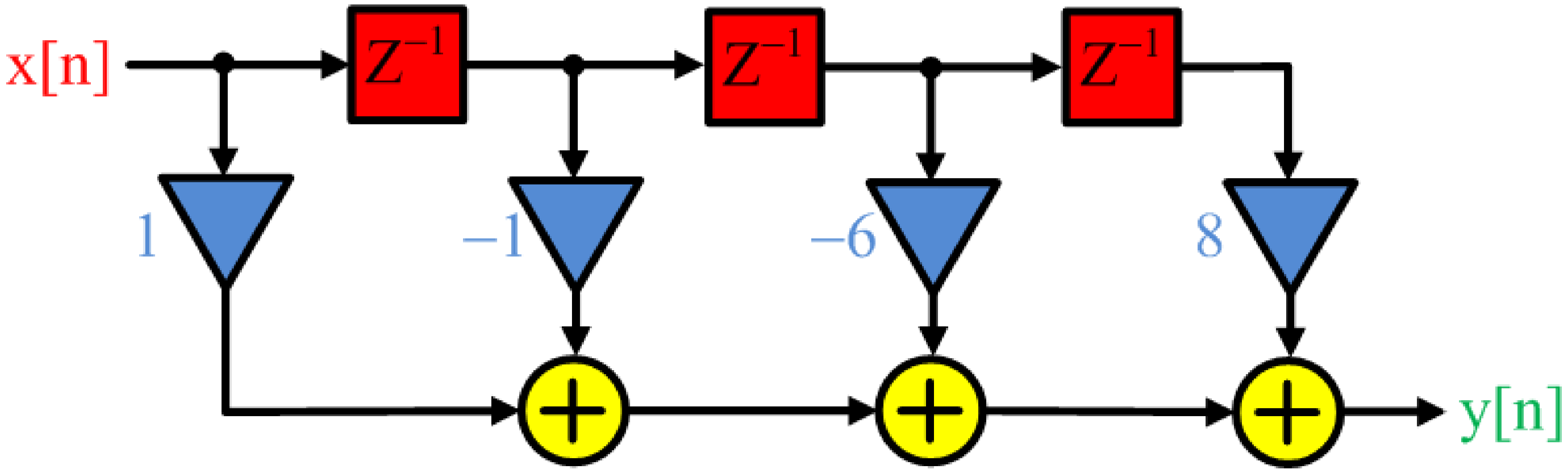
Since the transfer function has only the numerator part or zeroes, therefore this is an FIR filter.

$$H(z) = \frac{y[z]}{x[z]} = (1-2z^{-1})(1+ z^{-1}-4\, z^{-2})$$

Solution

$$Y(z) = X(z) - z^{-1}X(z) - 6z^{-2}X(z) + 8z^{-3}X(z)$$

$$y(n) = x(n) - x(n-1) - 6x(n-2) + 8x(n-3)$$



Direct-form IIR structures

- M^{th} order IIR filters are characterized by 2N + 1 coefficients and, require 2N + 1 multipliers and 2N two-input adders.

- For IIR filters in which the multiplier coefficients are precisely the coefficients of the transfers function are called direct-form structures.

Direct-form-I IIR structures

Consider the transfer function for N-th order IIR filter:

$$H(z) = \frac{Y(z)}{X(z)} = \frac{P_0 + P_1 z^{-1} + \cdots + P_N z^{-N}}{1 + d_1 z^{-1} + \cdots + d_N z^{-N}}$$

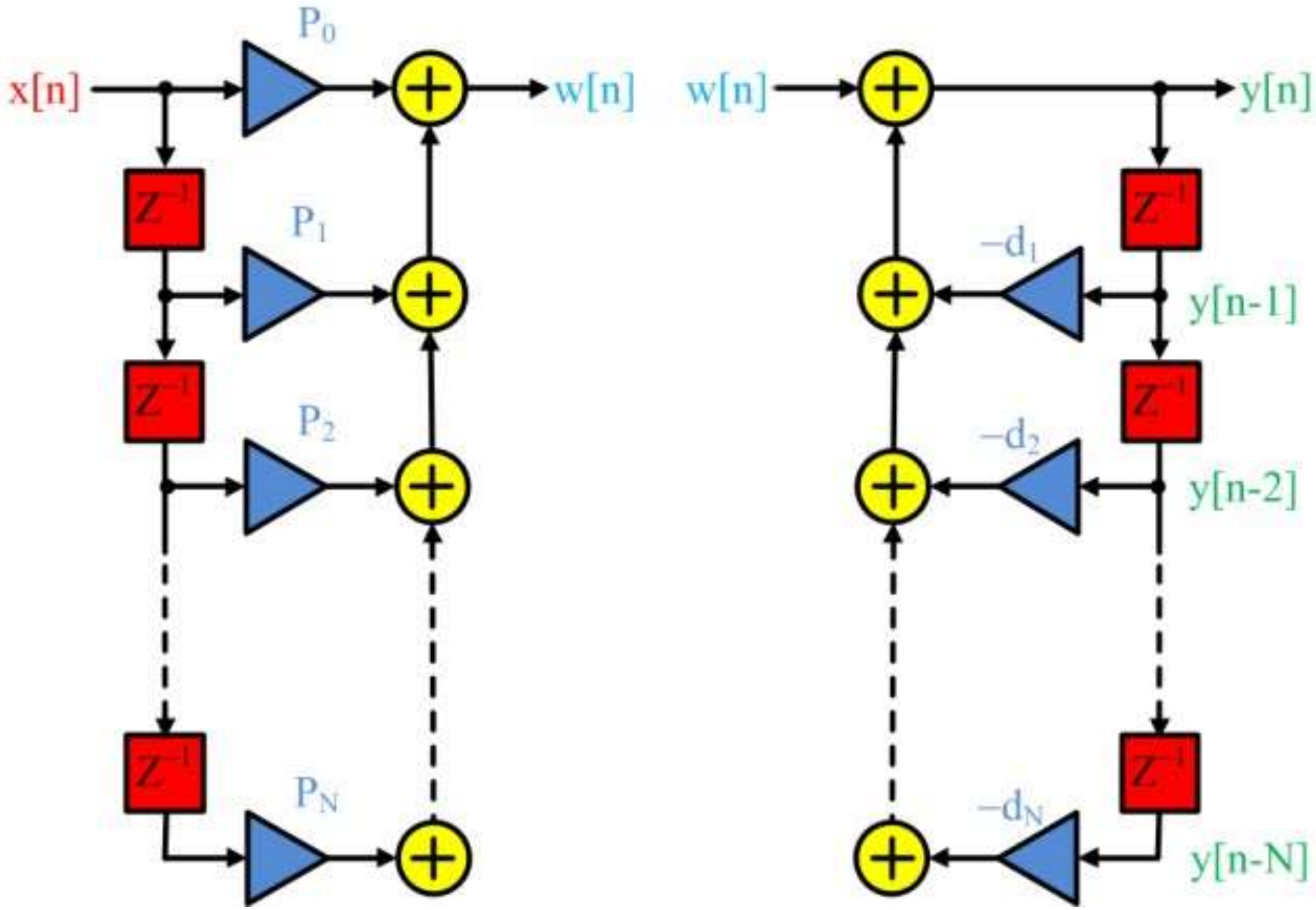
$$H_1(z) = \frac{W(z)}{X(z)}$$

$$= P_Z = P_0 + P_1 z^{-1} + \cdots + P_N z^{-N}$$

Direct-form-I IIR structures

$$H_2(z) = \frac{Y(z)}{W(z)} = \frac{1}{D(z)}$$

$$= \frac{1}{1 + d_1 z^{-1} + \cdots + d_N z^{-N}}$$



Example

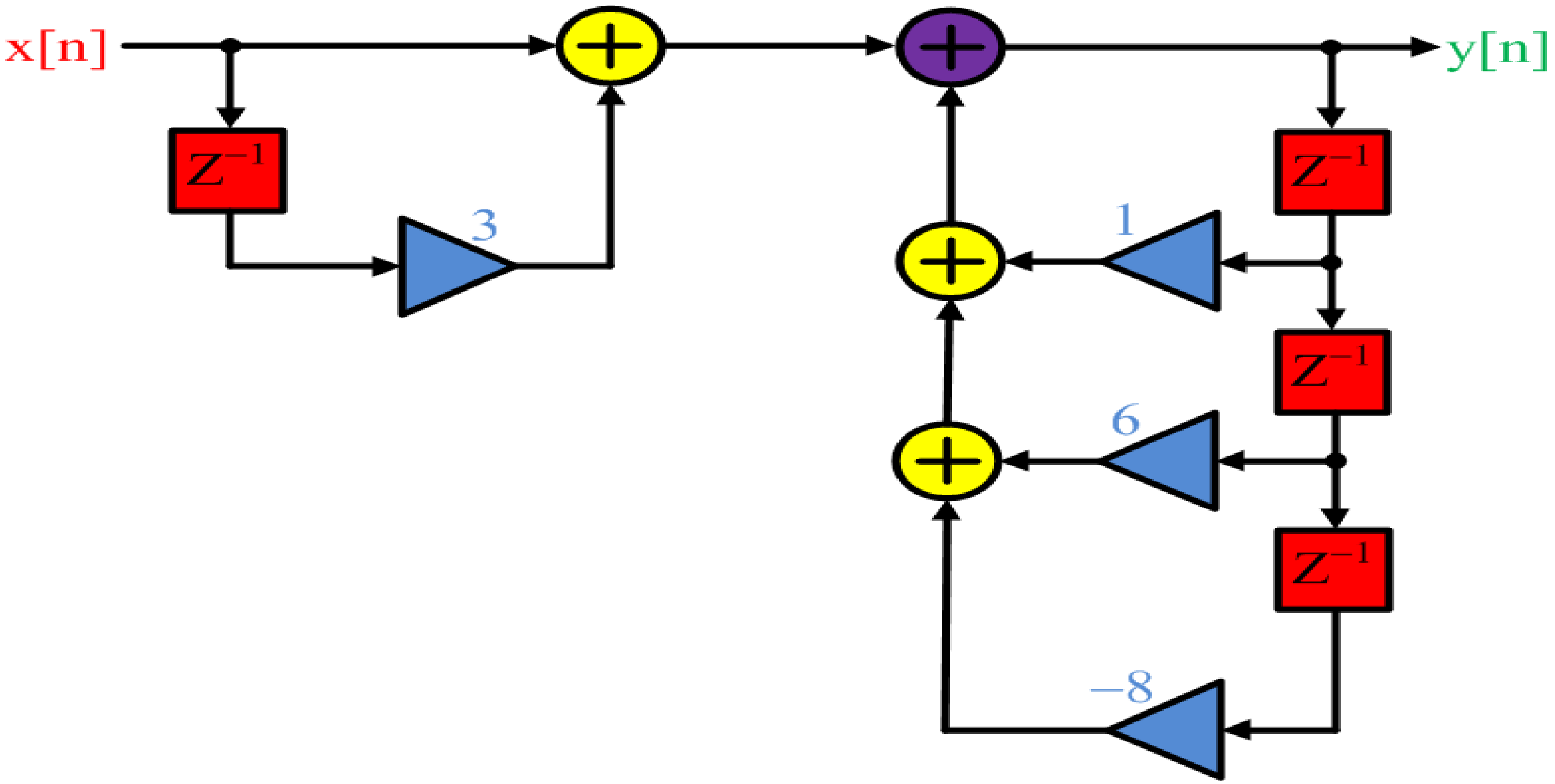
Realize the infinite impulse response (IIR) filter using the direct form-I from the transfer function:

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

$$H(z) = \frac{Y(z)}{X(z)} = \frac{1+3z^{-1}}{1-z^{-1}-6z^{-2}+8z^{-3}}$$

$$Y(z) = z^{-1}Y(z) + 6z^{-2}Y(z) - 8z^{-3}Y(z) + X(z) + 3z^{-1}X(z)$$

Solution



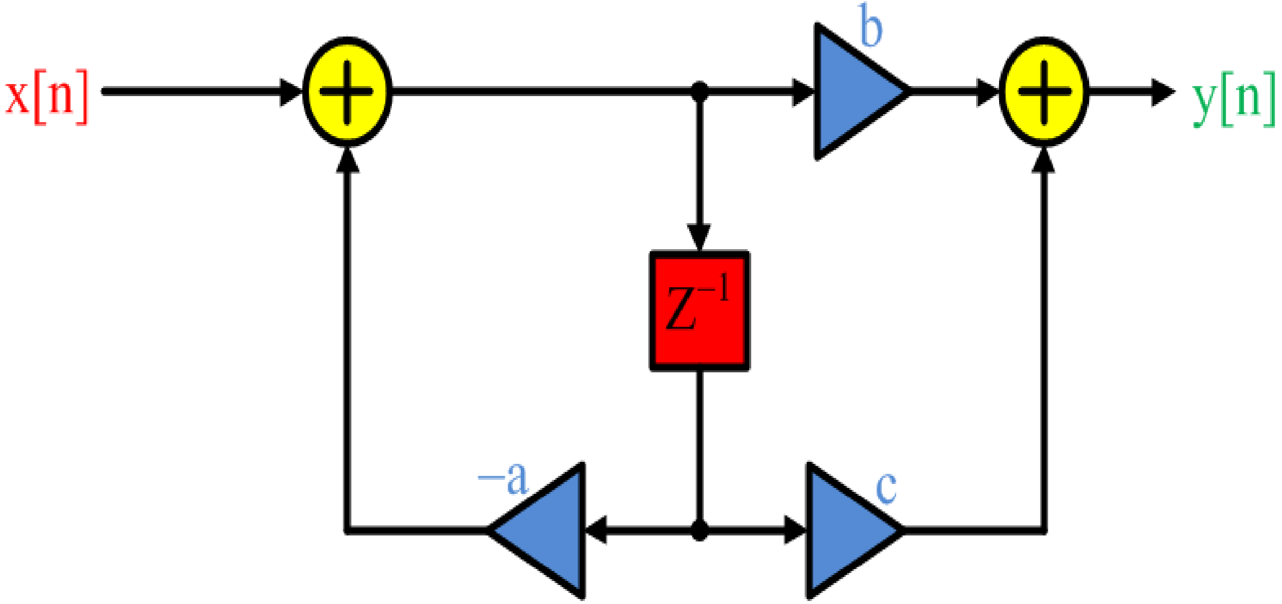
Example

Realize the infinite impulse response (IIR) filter using the direct form-II from the transfer function:

$$y(n) + ay(n-1) = bx(n) + cx(n-1)$$

Rearranging the difference equation:

$$y(n) = -ay(n-1) + bx(n) + cx(n-1)$$



Direct-form-II IIR structures