2.4 Frequency transformation in the analog domain. Structure of IIR filter - direct form I, direct form II, Cascade, parallel realizations.

STRUCTURES FOR IIR SYSTEMS:

IIR Systems are represented in four different ways

1. Direct Form Structures Form I and Form II
2. Cascade Form Structure
3. Parallel Form Structure
4. Lattice and Lattice-Ladder structure.

DIRECT FORM-I :

Challenge: Obtain the direct form-I, direct form-II,Cascade and parallel form realization of the system y(n)=-0.1y(n-1)+0.2y(n-2)+3x(n)+3.6x(n-1)+0.6x(n-2) [April/May-2015]

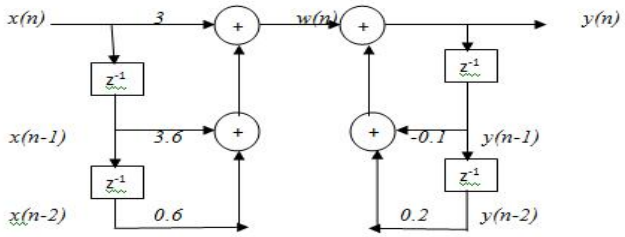
Solution:

Direct Form I:

$Let\ 3x(n)+3.6x(n-1)+0.6x(n-2)=w(n)$

$y(n)=-0.1y(n-1)+0.2y(n-2)+w(n)$

The direct form I realization is

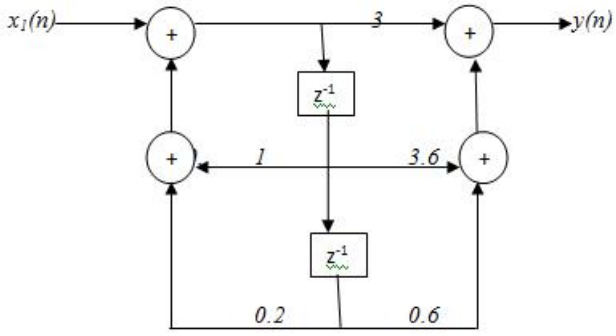


Direct form II:

From the given difference equation we have

$$H(z)=\frac{Y(z)}{X(z)}=\frac{3+3.6z^{-1}+0.6z^{-2}}{1+0.1z^{-1}-0.2z^{-2}}$$

The above system function can be realized in direct form II



Cascade Form:

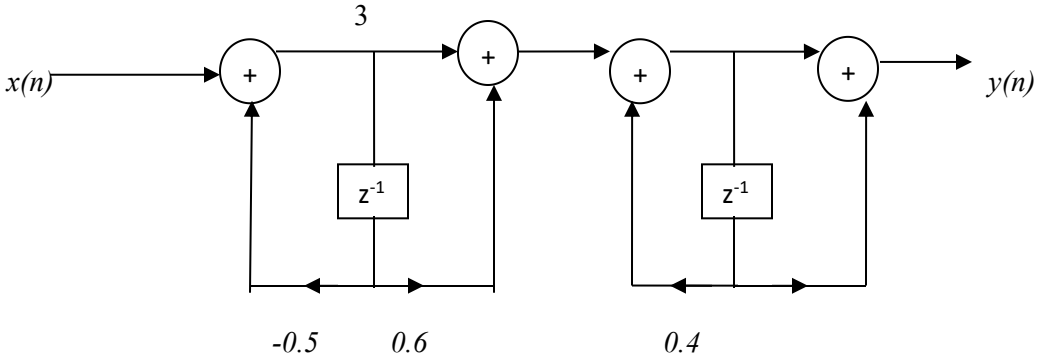
$$\frac{Y(z)}{X(z)} = \frac{3+3.6z^{-1}+0.6z^{-2}}{1+0.1z^{-1}-0.2z^{-2}}$$

$$= \frac{(3+0.6z^{-1})(1+z^{-1})}{(1+0.5z^{-1})(1-0.4z^{-1})}$$

$$H_1(z) = \frac{3+0.6z^{-1}}{1+0.5z^{-1}}$$

$$H_2(z) = \frac{1+z^{-1}}{1-0.4z^{-1}}$$

Now we realize $H_1(z)$ *and* $H_2(z)$ and cascade both to get realization of H(z)

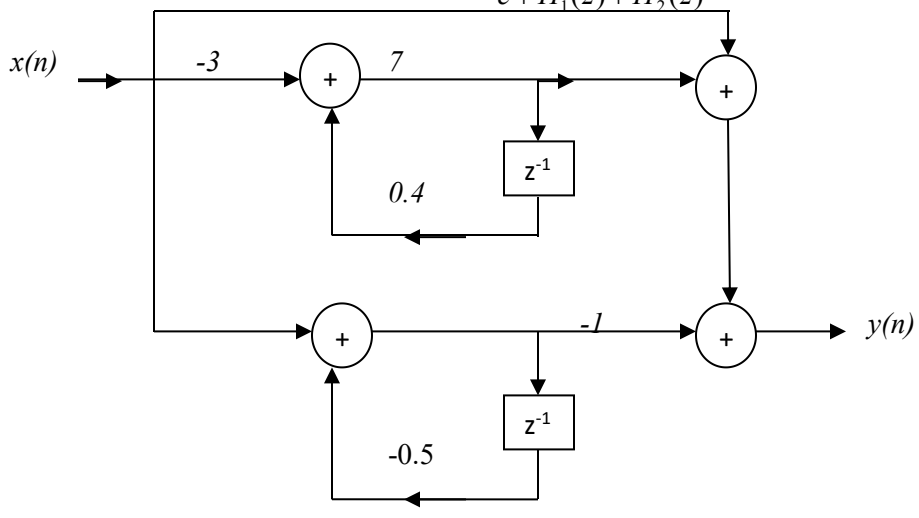


Parallel form:

$$H(z) = \frac{3+3.6z^{-1}+0.6z^{-2}}{1+0.1z^{-1}-0.2z^{-2}}$$

$$= -3 + \frac{7}{1-0.4z^{-1}} - \frac{1}{1+0.5z^{-1}}$$

$$= c + H_1(z) + H_2(z)$$



Direct form I:

H.W: Obtain the direct form-I realization for the system described by the following difference equations.

$(i)\quad y(n) = 2y(n-1) + 3y(n-2) + x(n) + 2x(n-1) + 3x(n-2)$

$(ii)\quad y(n) = 0.5y(n-1) + 0.06y(n-2) + 0.3x(n) + 0.5x(n-1)$

Obtain the direct form-I realization for the system described by difference equation

$y(n) = 0.5y(n-1) - 0.25y(n-2) + x(n) + 0.4x(n-1)$

Direct form II

H.W: Determine the direct form II realization for the following system

$(i)\ y(n) + y(n-1) - 4y(n-3) = x(n) + 3x(n-2)$

$(ii)\ y(n) = \frac{3}{4}y(n-1) - \frac{1}{8}y(n-2) + x(n) + \frac{1}{2}x(n-1)$ **[May/June-14]**

Determine the direct form II realization for the following system

$y(n) = -0.1y(n-1) + 0.72y(n-2) + 0.7x(n) - 0.252x(n-2)$

CASCADE FORM:

H.W: For the system function $H(z) = \dfrac{1 + 2z^{-1} + z^{-2}}{1 - \frac{3}{4}z^{-1} + \frac{1}{8}z^{-2}}$ **obtain cascade structure.**

Realize the system with difference equation $y(n) = \frac{3}{4}y(n-1) - \frac{1}{8}y(n-2) + x(n) + \frac{1}{3}x(n-1)$ **in cascade form.**

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Parallel form:

H.W: Realize the system given by difference equation

$y(n) = -0.1y(n-1) + 0.72y(n-2) + 0.7x(n) - 0.252x(n-2)$ **in parallel form.**

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Analog filter design:

There are two types of analog filter design are,

- Butterworth Filter
- Chebyshev Filter.

Analog Low pass Butterworth Filter:

N	Denominator of H(s)
1	$S+1$
2	$s^2 + \sqrt{2}s + 1$
3	$(s+1)(s^2+s+1)$
4	$(s^2 + 0.76537s + 1)(s^2 + 1.8477s + 1)$
5	$(s+1)(s^2 + 0.61803s + 1)(s^2 + 1.61803s + 1)$
6	$(s^2 + 1.931855s + 1)(s^2 + \sqrt{2}s + 1)(s^2 + 0.51764s + 1)$
7	$(s+1)(s^2 + 1.80194s + 1)(s^2 + 1.247s + 1)(s^2 + 0.445s + 1)$