USN | | | | | | | | | |

## IMPROVEMENT TEST

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|---|---|---|---|---|---|---|---|---|---|---|
| Sub: | DIGITAL SIGNAL PROCESSING | | | | | | | | Code: | 15EC52 |
| Date: | 18 / 11 / 2017 | Duration: | 90 mins | Max Marks: | 50 | Sem: | V | | Branch: | ECE(C,D), TCE(A,B) |

**Answer any 5 full questions**

| No. | Question | Marks | CO | RBT |
|---|---|---|---|---|
| 1. | Design an analog Butterworth filter with a maximum passband ripple of 2 dB at 1 rad/sec and stopband attenuation of 30 dB at 3 rad/sec. | [10] | CO502.3 | L3 |
| 2. | Design an analog Type-I Chebyshev filter with a maximum passband ripple of 2 dB at 1 rad/sec and stopband attenuation of 30 dB at 2 rad/sec. | [10] | CO502.3 | L3 |
| 3. | Explain the impulse invariant transformation method of transforming an analog filter transfer function to digital filter transfer function. | [10] | CO502.3 | L2 |
| 4. | Explain bilinear transformation method of transforming an analog filter transfer function to digital filter transfer function. | [10] | CO502.3 | L2 |
| 5. | Obtain DF-I and DF-II structure of the filter given by $$H(z) = \frac{(z-1)(z^2+5z+6)(z-3)}{(z^2+6z+5)(z^2-6z+8)}$$ | [10] | CO502.4 | L2 |
| 6. | Obtain the cascade and parallel realization of the system $$H(z) = \frac{1+\frac{1}{3}z^{-1}}{(1-\frac{1}{5}z^{-1})(1-\frac{3}{4}z^{-1}+\frac{1}{8}z^{-2})}$$ | [10] | CO502.4 | L2 |
| 7. | An FIR filter is represented by the difference equation $$y(n) = x(n) + \frac{2}{5}x(n-1) + \frac{3}{4}x(n-2) + \frac{1}{3}x(n-3).$$ Obtain the lattice structure. | [10] | CO502.4 | L2 |
| 8(a). | Realize the FIR filter having the following impulse response, using linear phase structure. $$h(n) = \delta(n) - \frac{1}{4}\delta(n-1) + \frac{1}{2}\delta(n-2) + \frac{1}{2}\delta(n-3) - \frac{1}{4}\delta(n-4) + \delta(n-5)$$ | [06] | CO502.4 | L2 |
| 8(b). | Mention the four types of analog to analog frequency transformations. | [04] | CO502.3 | L1 |

# Solutions



1 $A_{PB} = 2\,dB$

$A_{SB} = 30\,dB$

$\Omega_{PB} = 1\,rad/s$

$\Omega_{SB} = 3\,rad/s$

$$N = \frac{0.5\log_{10}\left(\dfrac{10^{0.1A_{PB}}-1}{10^{0.1A_{SB}}-1}\right)}{\log_{10}\left(\dfrac{\Omega_{PB}}{\Omega_{SB}}\right)} = 4$$

$$\Omega_c = \frac{\Omega_{PB}}{\left[10^{0.1A_{PB}}-1\right]^{\frac{1}{2N}}} = 1.0693\,rad/s$$

$$s_{0,3} = -0.4092 \pm j0.9879$$

$$s_{1,3} = -0.9879 \pm j0.4092$$

$$H(s) = \frac{(-1)^N \prod_{k=0}^{N-1} s_k}{\prod_{k=0}^{N-1}(s-s_k)}$$

$$= \frac{1.3074}{(s^2+0.8184s+1.1435)(s^2+1.9759s+1.1435)}$$

2 $A_{PB} = 2\ dB$

$A_{SB} = 30\ dB$

$\Omega_{PB} = 1\ rad/s$

$\Omega_{SB} = 2\ rad/s.$

$$N = \frac{\cosh^{-1}\left(\sqrt{\dfrac{10^{0.1A_{SB}}-1}{10^{0.1A_{PB}}-1}}\right)}{\cosh^{-1}\left(\dfrac{\Omega_{SB}}{\Omega_{PB}}\right)} = 4$$

$$\varepsilon = \sqrt{10^{0.1A_{PB}}-1} = 0.7648$$

$$R = \left[\frac{1+\sqrt{1+\varepsilon^2}}{\varepsilon}\right]^{\frac{1}{N}} = 1.311$$

$$s_{0,3} = -0.1049 \pm j0.958$$

$$s_{1,2} = -0.2532 \pm j0.3968$$

$$H(s) = \frac{0.1634}{(s^2+0.2098s+0.9287)(s^2+0.5064s+0.2216)}$$

3 $$H(s) = \sum_{k=1}^{N} \frac{b_k}{s - P_k}$$

$$h(t) = \sum_{k=1}^{N} b_k e^{P_k t}$$

$$h(n) = \sum_{k=1}^{N} b_k e^{P_k n T_s}$$

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

$$= \sum_{k=1}^{N} \frac{b_k}{1 - e^{P_k T_s} z^{-1}}$$

$$\omega = \Omega T_s.$$

Mapping is unique only in the range

$$-\frac{f_s}{2} \le \Omega \le \frac{f_s}{2}$$

4. $$H(s) = \frac{b}{s+a}$$

$$\frac{d}{dt} y(t) + a y(t) = b x(t)$$

$$\int_{nT_s - T_s}^{nT_s} \frac{d}{dt} y(t) dt + a \int_{nT_s - T_s}^{nT_s} y(t) = b \int_{nT_s - T_s}^{nT_s} x(t) dt$$

$$\left(1+\frac{aT_s}{2}\right) y(n) - \left(1-\frac{aT_s}{2}\right) y(n-1)$$

$$= \frac{bT_s}{2}\left[x(n)+x(n-1)\right]$$

$$H(z) = \frac{b}{a + \frac{2}{T_s}\,\frac{z-1}{z+1}}$$

$$\Omega = \frac{2}{T_s}\tan\left(\frac{\omega}{2}\right)$$

Hence, there is no aliasing.

5 $$H(z) = \frac{(z^2-4z+3)(z^2+5z+6)}{(z^2+6z+5)(z^2-6z+8)}$$

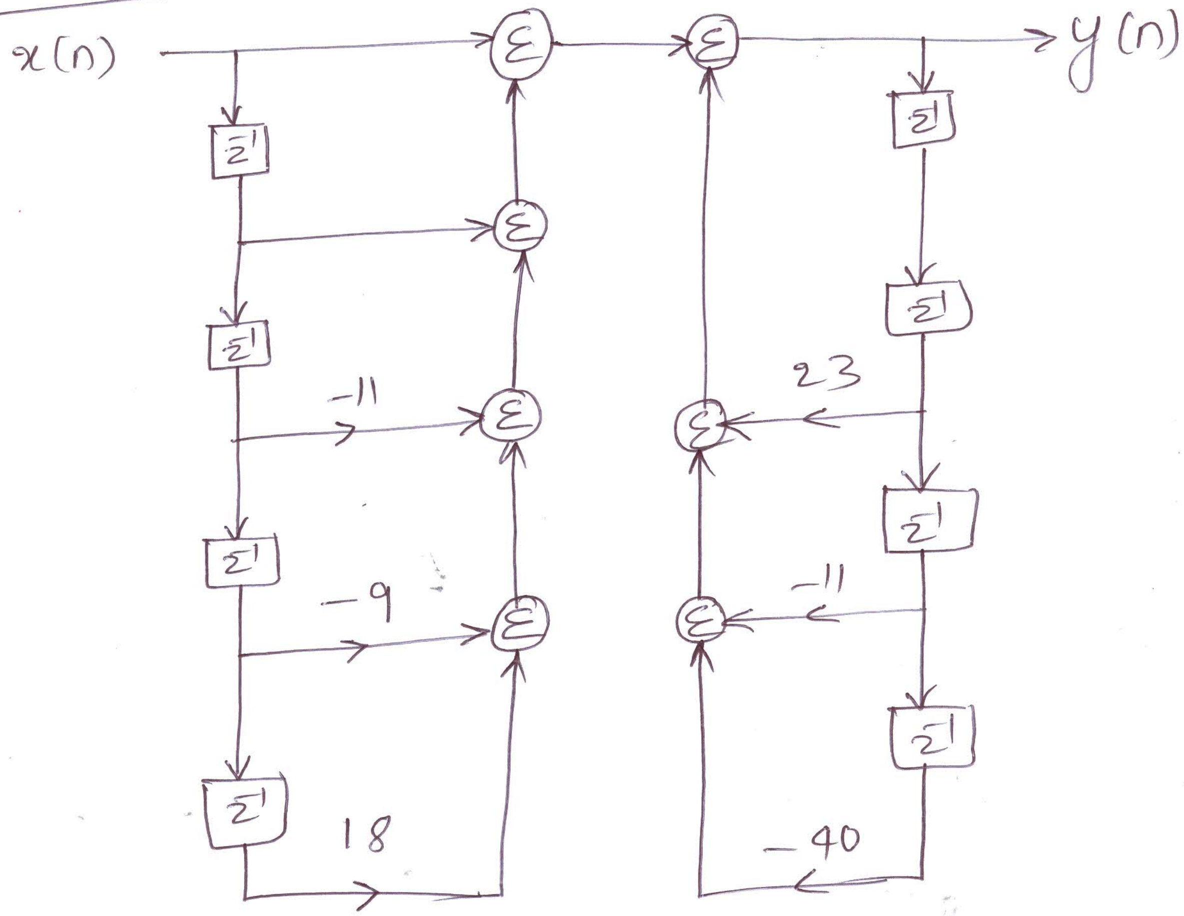
$$= \frac{z^4+5z^3+6z^2-4z^3-20z^2-24z+3z^2+15z+18}{z^4-6z^3+8z^2+6z^3-36z^2+48z+5z^2-30z+40}$$

$$= \frac{z^4+z^3-11z^2-9z+18}{z^4-23z^2+18z+40}$$

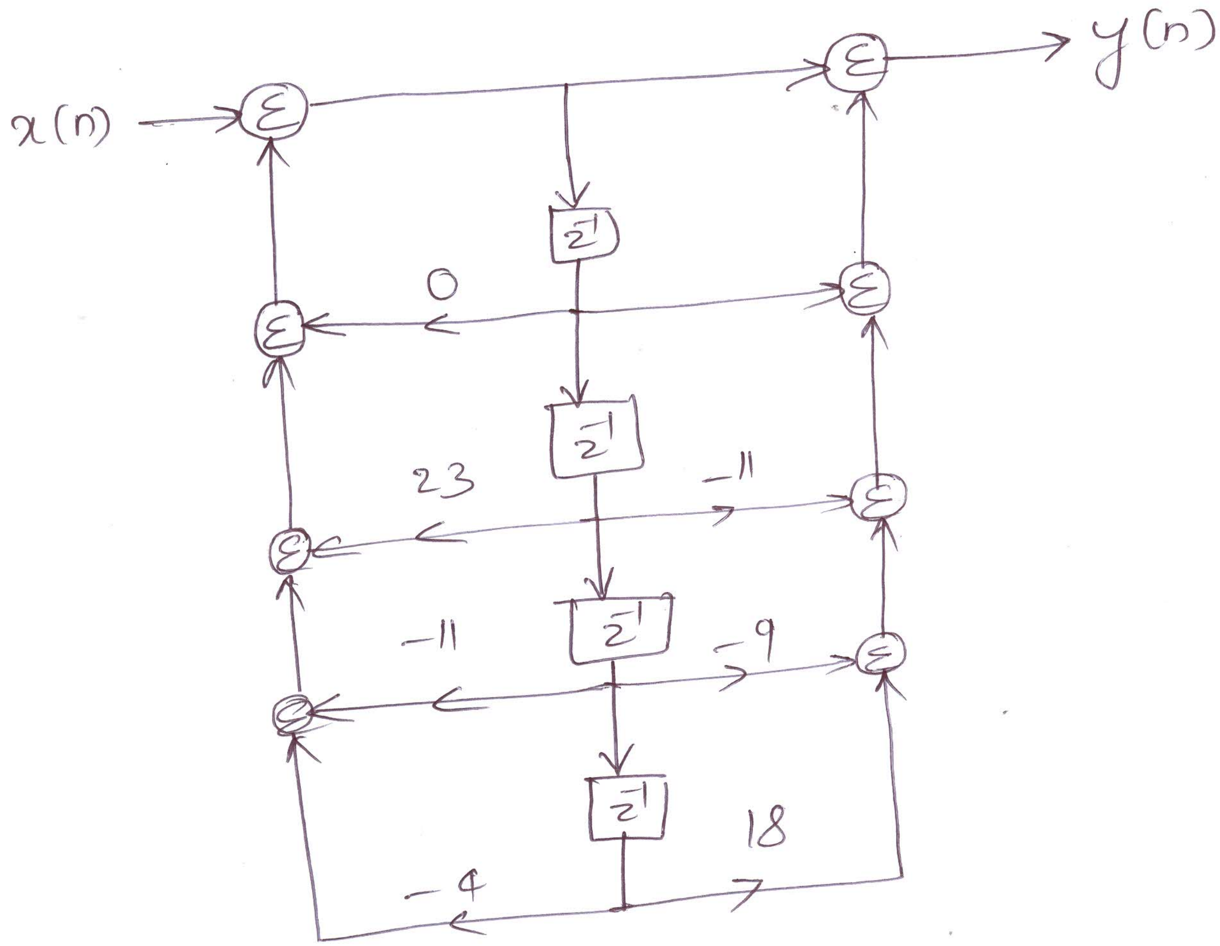
$$= \frac{1+z^{-1}-11z^{-2}-9z^{-3}+18z^{-4}}{1-23z^{-2}+11z^{-3}+40z^{-4}}$$

$$\therefore y(n) = x(n)+x(n-1)-11x(n-2)-9x(n-3)+18x(n-4)$$
$$+23y(n-2)-11y(n-3)-40y(n-4)$$

## DF – I


x(n)
y(n)
$z^{-1}$
$z^{-1}$
$z^{-1}$
$z^{-1}$
-11
-9
18
$z^{-1}$
$z^{-1}$
$z^{-1}$
$z^{-1}$
23
-11
-40

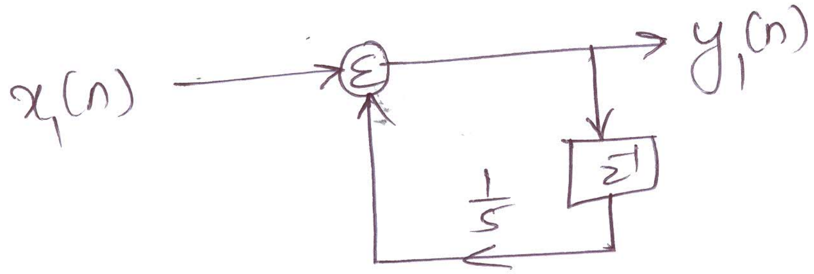
## DF – II


x(n)
y(n)
$z^{-1}$
0
$z^{-1}$
23
-11
$z^{-1}$
-11
-9
$z^{-1}$
18
-4

6 ## Cascade realization

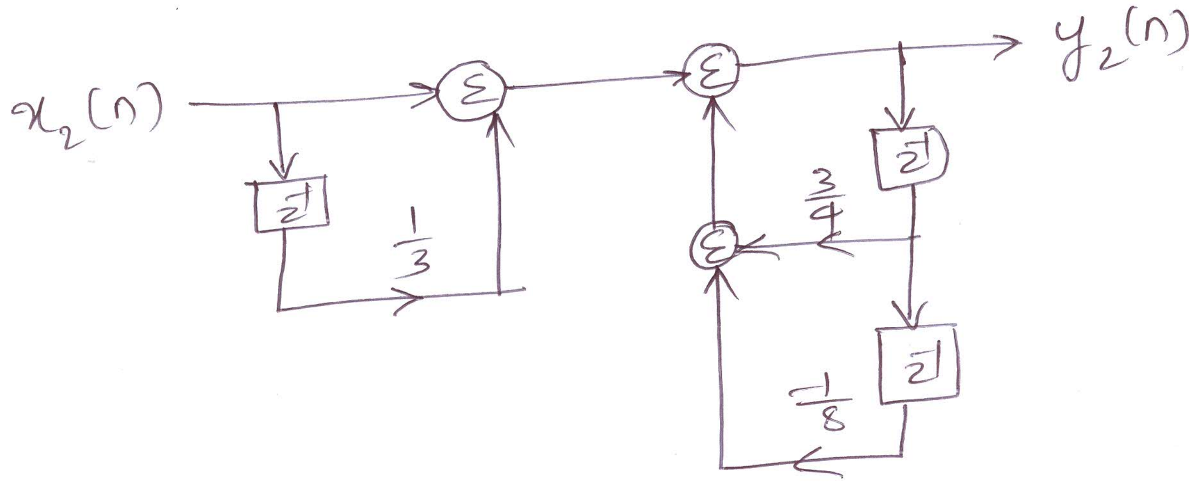
$$H_1(z) = \frac{1}{1-\frac{1}{5}z^{-1}}$$

$$y_1(n) = x_1(n) + \frac{1}{5}y_1(n-1)$$

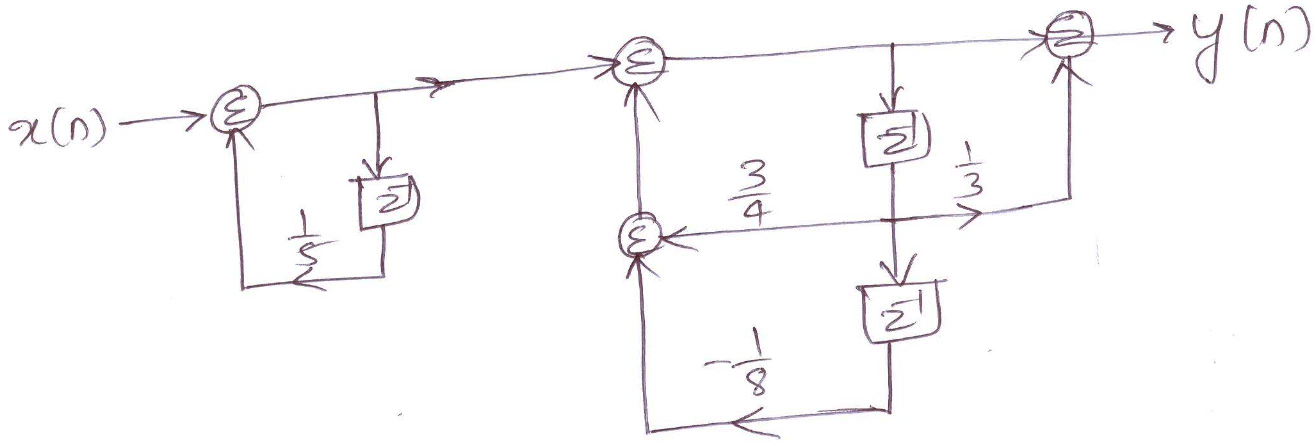



$$H_2(z) = \frac{1+\frac{1}{3}z^{-1}}{1-\frac{3}{4}z^{-1}+\frac{1}{8}z^{-2}}$$

$$y_2(n) = x_2(n) + \frac{1}{3}x_2(n-1) + \frac{3}{4}y_2(n-1) - \frac{1}{8}y_2(n-2).$$

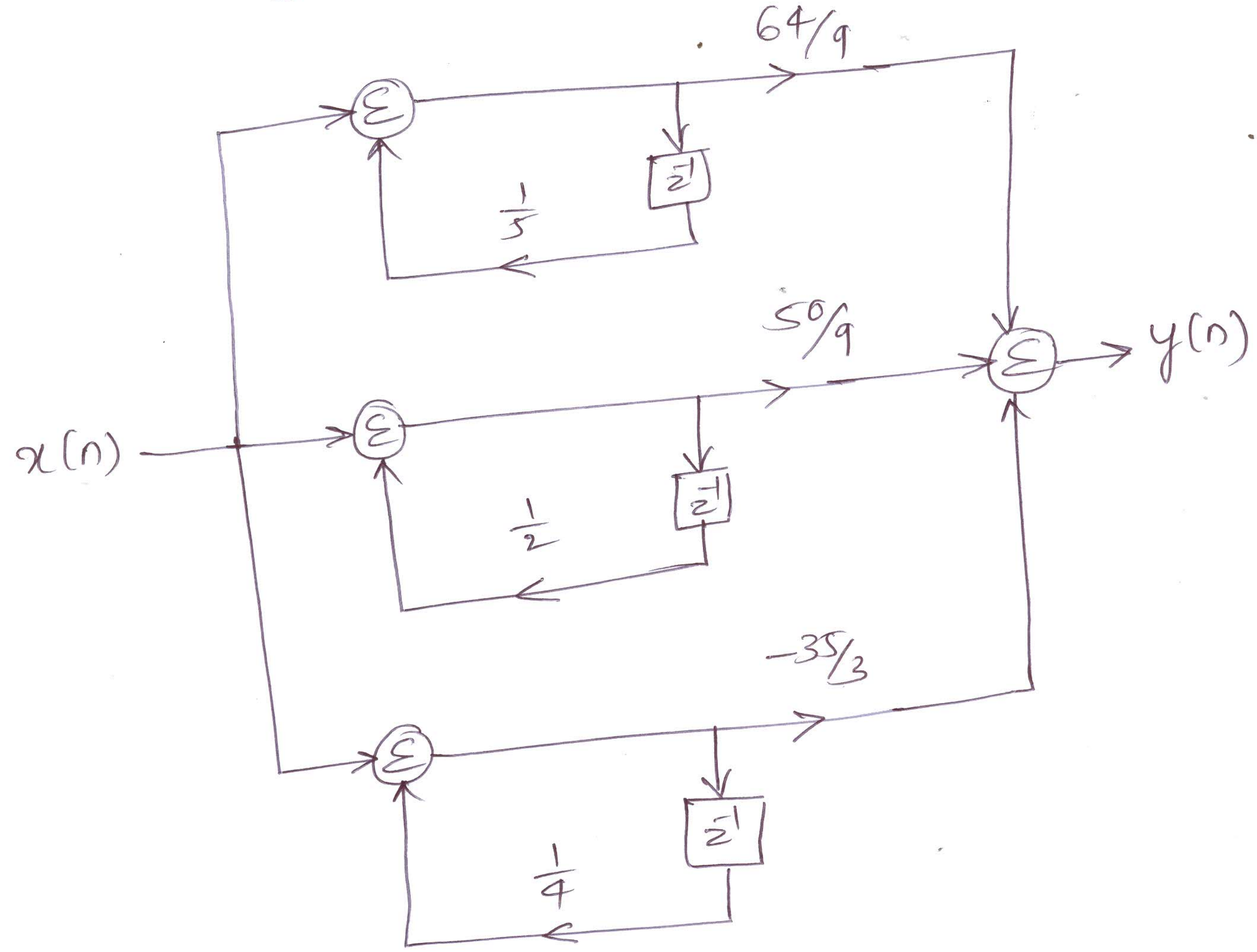


## Cascade realization




## Parallel realization

$$H(z) = \frac{64/9}{1-\frac{1}{5}z^{-1}} + \frac{50/9}{1-\frac{1}{2}z^{-1}} + \frac{-35/3}{1-\frac{1}{4}z^{-1}}$$



7 $K_3 = \frac{1}{3}$

$K_2 = \frac{111}{160}$

$K_1 = 0.0419$