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## III INTERNAL ASSESSMENT TEST

| Sub: | DIGITAL SIGNAL PROCESSING | | | | | | | Code: | 15EC52 |
|---|---|---|---|---|---|---|---|---|---|
| Date: | 19/ 11 / 2018 | Duration: | 90 mins | Max Marks: | 50 | Sem: | V | Branch: | ECE(D)/TCE |

**Answer any 5 full questions**

| | | Marks | CO | RBT |
|---|---|---|---|---|
| 1 | Explain Goertzel algorithm. Obtain the direct form II realization of Goertzel filter. | [10] | CO3 | L2 |
| 2(a) | Given x[n] = [2,0,2,0], obtain X[2] using Goertzel algorithm. | [04] | CO3 | L2 |
| 2(b) | Write a note on Chirp Z transform and its applications. | [06] | CO3 | L2 |
| 3 | Derive the frequency response of Type-I and Type-III digital FIR filters. Discuss the suitability of these types for the design of digital LPF, HPF, BPF, BSF. | [10] | CO4 | L2 |

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| 4 | The desired frequency response of a filter is<br>$$H_d(e^{j\omega}) = \begin{cases} e^{-j3\omega}, & -\frac{3\pi}{4} \le \omega \le \frac{3\pi}{4} \\ 0, & \frac{3\pi}{4} < \lvert\omega\rvert \le \pi \end{cases}$$<br>Determine the impulse response using Hamming window.<br>(Hamming Window Equation : $w(n) = 0.54 - 0.46\cos\left(\frac{2\pi n}{N-1}\right), 0 \le n \le N-1$) | [10] | CO4 | L2 |
| 5 | Obtain a cascade realization of the system described by<br>$$H(z) = \frac{\left(1+\frac{1}{4}z^{-1}\right)}{\left(1+\frac{1}{2}z^{-1}\right)\left(1+\frac{1}{2}z^{-1}+\frac{1}{4}z^{-2}\right)}$$ | [10] | CO4 | L2 |
| 6 | Obtain the parallel realization of the system function<br>$$H(z) = \frac{(1+z^{-1})(1+2z^{-1})}{\left(1+\frac{1}{2}z^{-1}\right)\left(1-\frac{1}{2}z^{-1}\right)\left(1+\frac{1}{8}z^{-1}\right)}$$ | [10] | CO4 | L2 |
| 7 | Obtain the direct form-I and direct form-II realizations of the following system function.<br>$$H(z) = \frac{(z-1)(z^2+5z+6)(z-3)}{(z^2+6z+5)(z^2-6z+8)}$$ | [10] | CO4 | L2 |


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# Solution and Scheme of Evaluation

1 $h(n) = W_N^{-kn}\, u(n)$ (2M)

$$y(n) = x(n) * h(n)$$

$$= \sum_{m=0}^{N-1} x(m)\, h(n-m)$$

$$= \sum_{m=0}^{N-1} x(m)\, W_N^{-k(n-m)} \quad (2M)$$

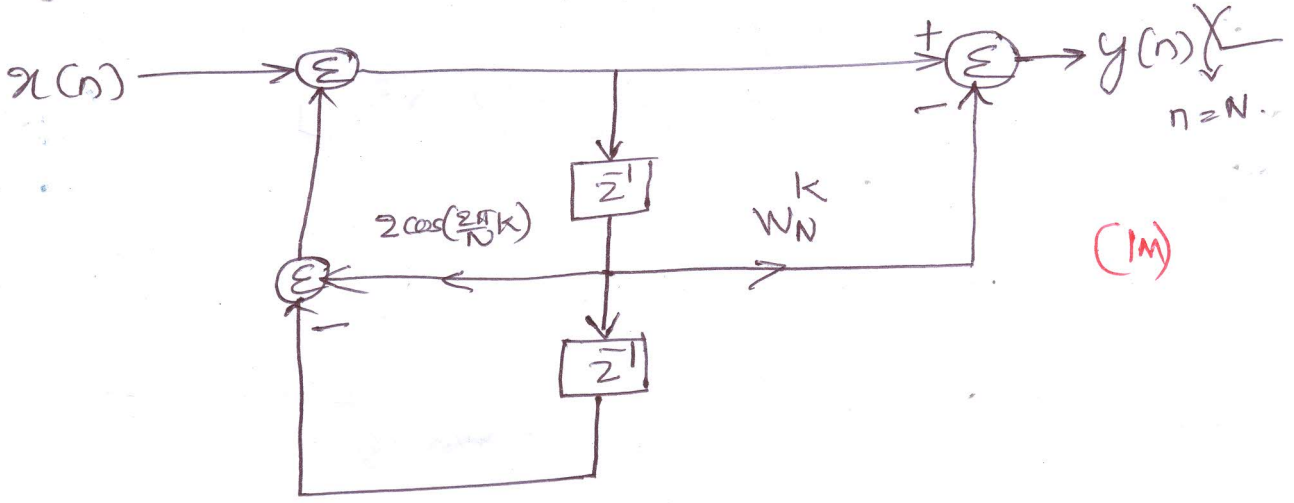
$$y(n)\Big|_{n=N} = \sum_{m=0}^{N-1} x(m)\, W_N^{+km}$$

$$= X(k). \quad (1M)$$

$$H(z) = \frac{1}{1 - W_N^{-k} z^{-1}} \quad (2M)$$

$$y(n) = x(n) + W_N^{-k}\, y(n-1)$$

$$H(z) = \frac{1 - W_N^{k} z^{-1}}{1 - 2\cos\left(\frac{2\pi}{N}k\right) z^{-1} + z^{-2}} \quad (2M)$$




(1M)

2a $x(n) = (2,0,2,0)$

$k = 2, \quad N = 4 \quad ; W_N^{-k} = e^{j\frac{2\pi}{4}2} = -1$

$y(n) = x(n) + W_N^{-k} y(n-1)$

$y(0) = x(0) = 2$

$y(1) = x(1) + (-1)y(0) = -2$

$y(2) = x(2) + (-1)y(1) = 2+2 = 4$ (4M)

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

$y(4) = x(4) + (-1)y(3) = 4$

2b $X(z_k) = \sum_{n=0}^{N-1} x(n) z_k^{-n}$

$z_k = r_0 e^{j\theta_0} (R_0 e^{j\phi_0})^k$ (2M)

$X(z_k) = \sum_{n=0}^{N-1} x(n) (r_0 e^{j\theta_0})^{-n} V^{-nk}$ (2M)

$= V^{-\frac{k^2}{2}} \sum_{n=0}^{N-1} g(n) V^{\frac{(k-n)^2}{2}}$

$= V^{-\frac{k^2}{2}} [\, g(k) * V^{\frac{k^2}{2}} \,]$ (2M)

3 Type 1 : N-odd, h(n) symmetric

$H(z) = z^{-\left(\frac{N-1}{2}\right)} \left[ h\left(\frac{N-1}{2}\right) + \sum_{n=0}^{\frac{N-3}{2}} h(n) \left\{ z^{+\left(\frac{N-1-2n}{2}\right)} + z^{-\left(\frac{N-1-2n}{2}\right)} \right\} \right]$ (2M)

$H(\omega) = e^{-j\left(\omega\left(\frac{N-1}{2}\right)\right)} \left[ h\left(\frac{N-1}{2}\right) + \sum_{n=0}^{\frac{N-3}{2}} h(n) 2\cos\left(\omega\left(\frac{N-1-2n}{2}\right)\right) \right]$ (3M)

Type 3 N - odd, $h(n)$ – antisymmetric

$$H(z) = z^{-\left(\frac{N-1}{2}\right)} \left[ \sum_{n=0}^{\frac{N-3}{2}} h(n) \left\{ z^{+\left(\frac{N-1-2n}{2}\right)} - z^{-\left(\frac{N-1-2n}{2}\right)} \right\} \right]$$

(2M)

$$H(\omega) = e^{-j\omega\left(\frac{N-1}{2}\right)} \left[ \sum_{n=0}^{\frac{N-3}{2}} h(n)\, 2j \sin\left(\omega\left(\frac{N-1-2n}{2}\right)\right) \right]$$

(3M)

4 $\alpha = 3$, $N = 7$, $\omega_c = \frac{3\pi}{4}$.

$$h_d(n) = \begin{cases} \dfrac{\sin\left(\frac{3\pi}{4}(n-3)\right)}{\pi(n-3)}, & n \neq 3 \\ \dfrac{3}{4}, & n = 3. \end{cases}$$

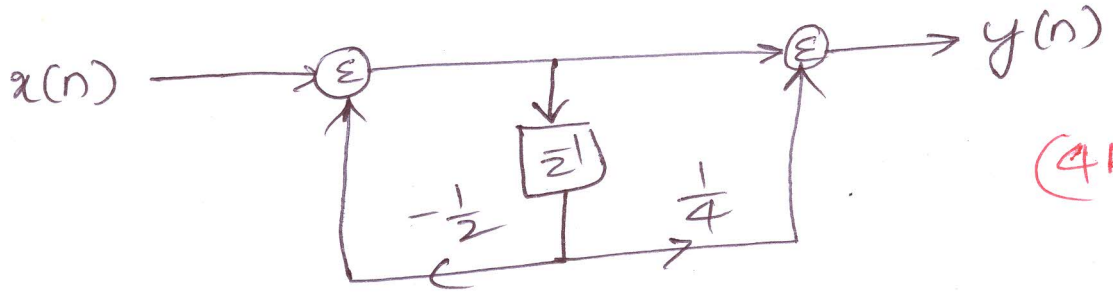
(5M)

| n | $h_d(n)$ | $\omega(n)$ | $h(n)$ |
|---|---|---|---|
| 0 | 0.075 | 0.08 | 0.006 |
| 1 | −0.159 | 0.31 | −0.0493 |
| 2 | 0.225 | 0.77 | 0.1733 |
| 3 | 0.75 | 1 | 0.75 |
| 4 | 0.225 | 0.77 | 0.1733 |
| 5 | −0.159 | 0.31 | −0.0493 |
| 6 | 0.075 | 0.08 | 0.006 |

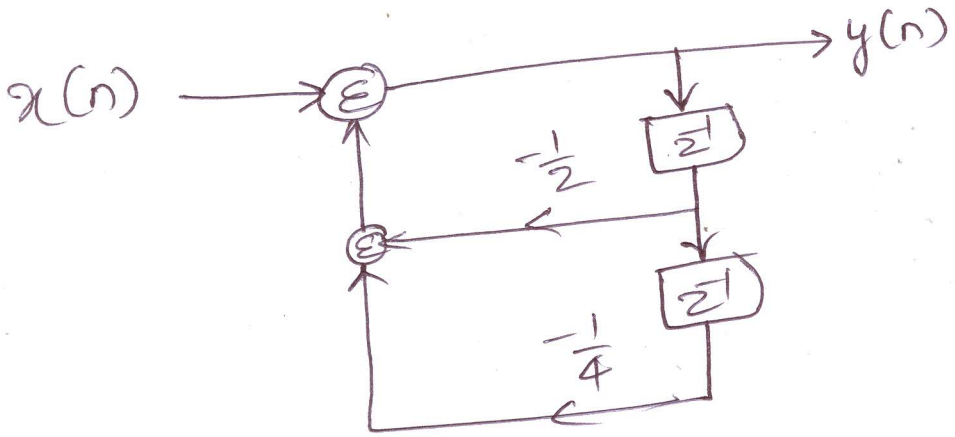
(5M)

5 $H_1(z) = \dfrac{1+\frac{1}{4}z^{-1}}{1+\frac{1}{2}z^{-1}}$.

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

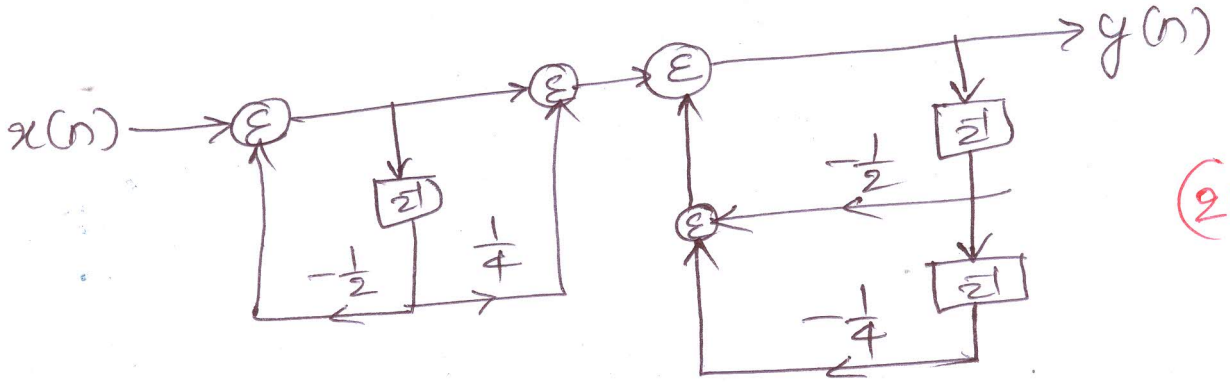



(4M)




(4M)

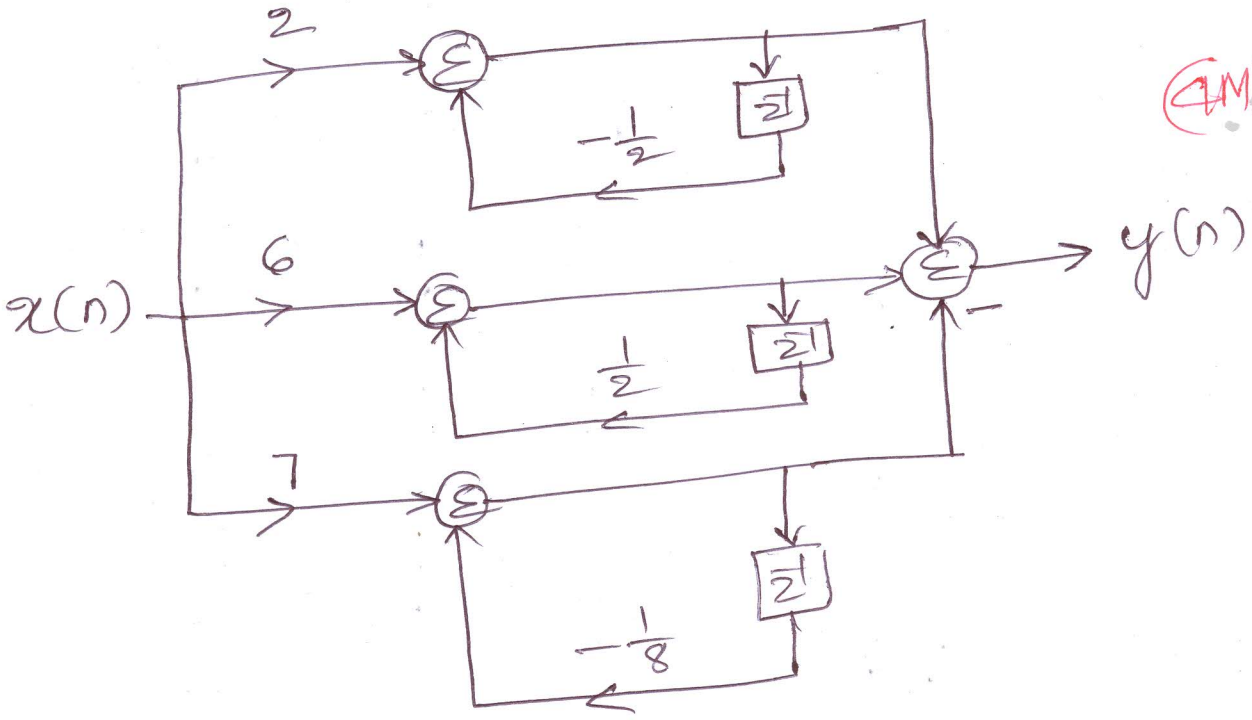
Cascade realization




(2M)

6 $H(z) = \frac{2}{1+\frac{1}{2}z^{-1}} + \frac{6}{1-\frac{1}{2}z^{-1}} - \frac{7}{1+\frac{1}{8}z^{-1}}$

(2M) (2M) (2M)




(4M)

7 $H(z) = \frac{(z-1)(z-3)(z^2+5z+6)}{(z^2+6z+5)(z^2-6z+8)}$

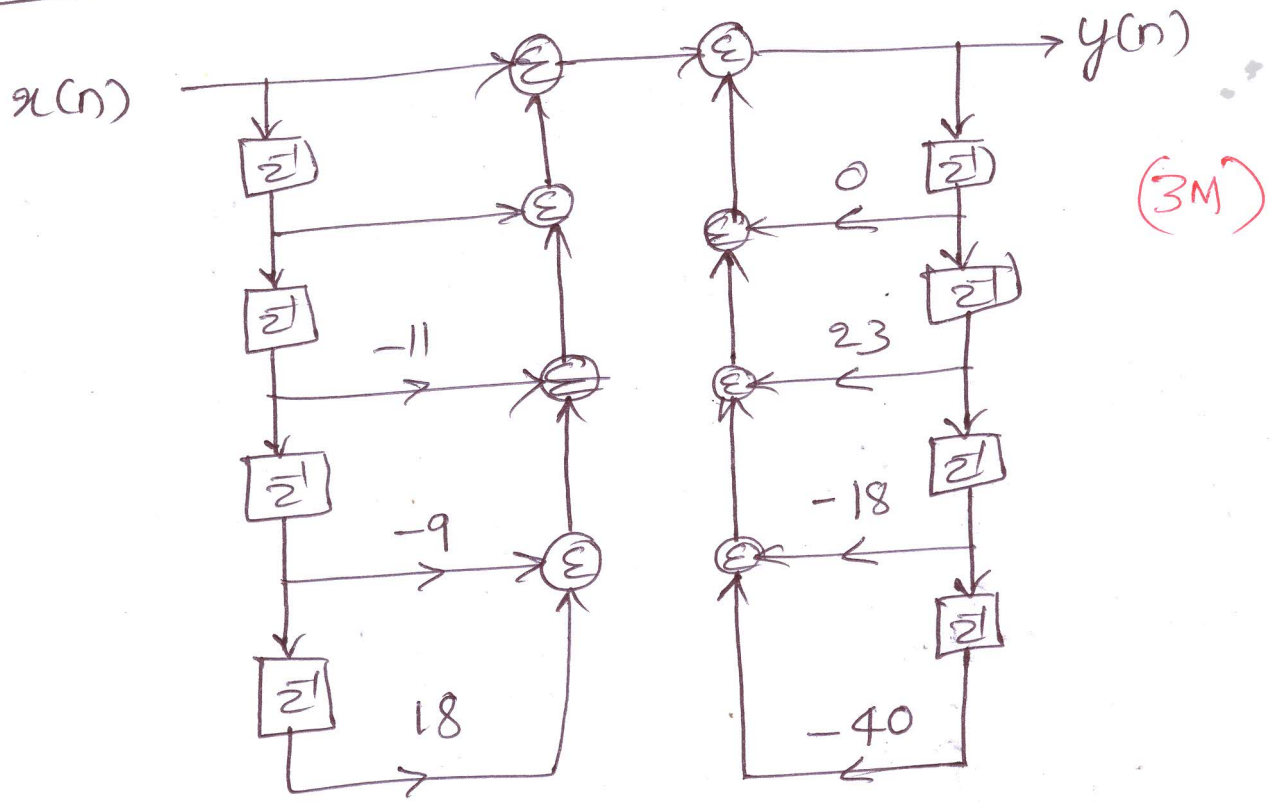
$= \frac{(z^2-4z+3)(z^2+5z+6)}{(z^2+6z+5)(z^2-6z+8)}$

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

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

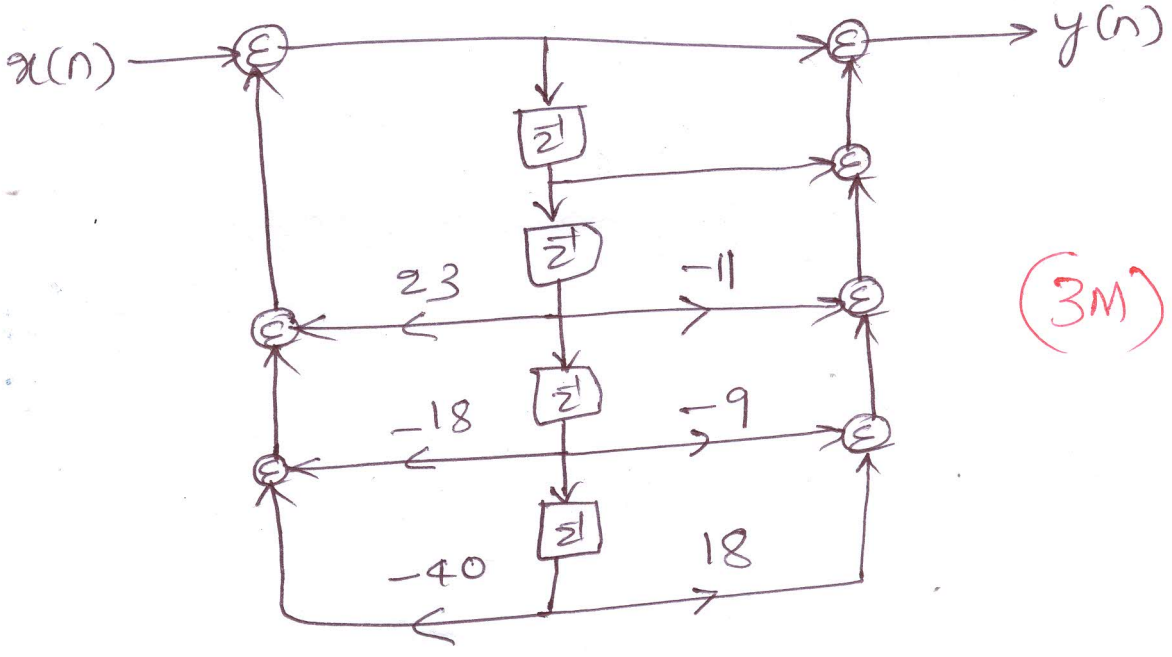
$$= \frac{1+z^{-1}-11z^{-2}-9z^{-3}+18z^{-4}}{1-23z^{-2}+18z^{-3}+40z^{-4}}$$

DF-I




(3M)

DF-II




(3M)