USN

INTERNAL ASSESSMENT TEST – III

Sub:	DIGITAL SIGNAL PROCESSING							Code:	17EC52
Date:	16/11 / 2019	Duration:	90 mins	Max Marks:	50	Sem:	V	Branch:	ECE(D)/TCE

Answer all questions

		Marks	CO	RBT
1	Explain Goertzel algorithm. Obtain direct form II implementation of Goertzel algorithm.	[10]	CO3	L3
2	Design an analog Butterworth filter to meet the following specifications. Passband attenuation of 2dB at 1 rad/s Stopband attenuation of 30dB at 3 rad/s	[10]	CO4	L3
3	Design an analog Chebyshev filter to meet the following specifications. Passband attenuation of 2dB at 1 rad/s Stopband attenuation of 30dB at 2 rad/s	[10]	CO4	L3

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4	Design an FIR filter to meet the following specification. $$H(\omega) = \begin{cases} e^{-j3\omega} \ for \ -\frac{\pi}{4} \le \omega \le \frac{\pi}{4} \\ 0 \ for \ \frac{\pi}{4} < \lvert\omega\rvert < \pi \end{cases}$$ Use Hanning window in your design. Obtain the frequency response of the desired filter. (Hanning window equation : $w(n) = 0.5 - 0.5\cos\left(\frac{2\pi n}{N-1}\right), 0 \le n \le N-1$)	[10]	CO4	L3
5	Design an FIR filter to meet the following specification. $$H(\omega) = \begin{cases} 0 \quad for \ -\frac{\pi}{4} \le \omega \le \frac{\pi}{4} \\ e^{-j3\omega} \ for \ \frac{\pi}{4} < \lvert\omega\rvert < \pi \end{cases}$$ Use Hamming window in your design. Obtain the frequency response of the desired filter. (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	L3

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Scheme Of Evaluation

Internal Assessment Test III – November 2019

Sub:	DIGITAL SIGNAL PROCESSING							Code:	17EC52
Date:	16/11/ 2019	Duration:	90 mins	Max Marks:	50	Sem:	V	Branch:	ECE(D),TCE

Note: Answer All Questions

Question #		Description	Marks Distribution		Max Marks
1		Explain Goertzel algorithm. Obtain direct form II implementation of Goertzel algorithm.		10	10
		• Proving $X[k] = y[n]\ @n = N$ • Obtaining difference equation • Implementation of the system	3 4 3		
2		Design an analog Butterworth filter to meet the following specifications. Passband attenuation of 2dB at 1 rad/s Stopband attenuation of 30dB at 3 rad/s		10	10
		• Order of the filter • Pole location • Transfer function	2 4 4		
3		Design an analog Chebyshev filter to meet the following specifications. Passband attenuation of 2dB at 1 rad/s Stopband attenuation of 30dB at 2 rad/s		10	10
		• Order of the filter • Pole location • Transfer function	2 4 4		
4		Design an FIR filter to meet the following specification. $H(\omega) = \begin{cases} e^{-j3\omega} & for\ -\frac{\pi}{4} \le \omega \le \frac{\pi}{4} \\ 0 & for\ \frac{\pi}{4} < \lvert\omega\rvert < \pi \end{cases}$ Use Hanning window in your design. Obtain the frequency response of the desired filter. (Hanning window equation : $w(n) = 0.5 - 0.5\cos\left(\frac{2\pi n}{N-1}\right), 0 \le n \le N-1$)		10	10
		• Obtaining impulse response • Impulse response after windowing • Frequency response	4 3 3		
5		Design an FIR filter to meet the following specification. $H(\omega) = \begin{cases} 0 & for\ -\frac{\pi}{4} \le \omega \le \frac{\pi}{4} \\ e^{-j3\omega} & for\ \frac{\pi}{4} < \lvert\omega\rvert < \pi \end{cases}$ Use Hammiing window in your design. Obtain the frequency response of the desired filter. (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	10

		• Obtaining impulse response • Impulse response after windowing • Frequency response	4 3 3		

Solutions

1 $h(n) = W_N^{-kn} u(n)$

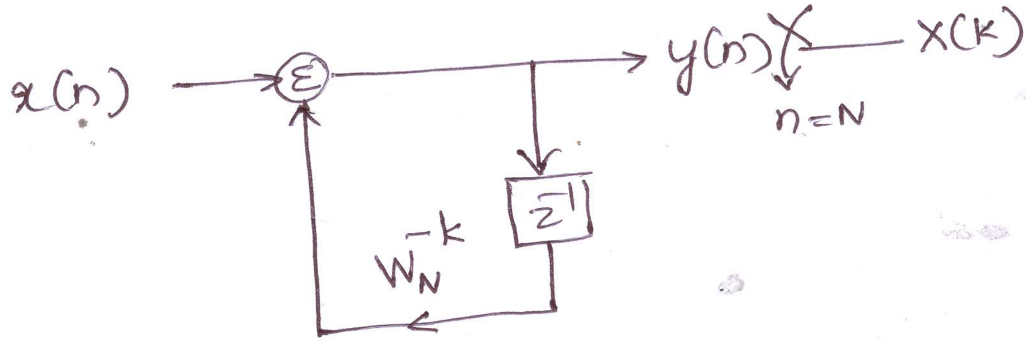
$$y(n) = x(n) * h(n)$$

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

$$y(n)\Big|_{n=N} = X(K)$$

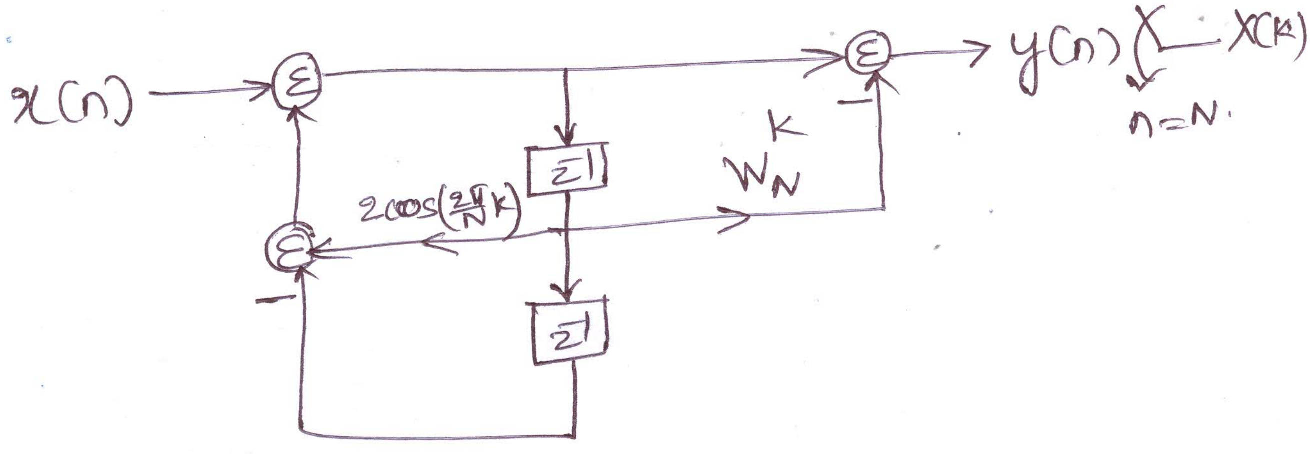
$$H(z) = \frac{1}{1 - W_N^{-k} z^{-1}}$$

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



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

$$y(n) = x(n) - W_N^{k} x(n-1) + 2\cos\left(\frac{2\pi}{N}k\right) y(n-1) - y(n-2)$$



2

$$N = \frac{\log_{10}\left[\frac{10^{0.1A_{PB}} - 1}{10^{0.1A_{SB}} - 1}\right]}{2\log\left(\frac{\Omega_{PB}}{\Omega_{SB}}\right)} \simeq 4$$

$$\Omega_C = \frac{\Omega_{PB}}{\left(10^{0.1A_{PB}} - 1\right)^{\frac{1}{2N}}} = 1.0693 \text{ rad/s}$$

$$S_K = \Omega_c\left[-\sin\left(\frac{(2K+1)\pi}{2N}\right) + j\cos\left(\frac{(2K+1)\pi}{2N}\right)\right]$$

$$S_0 = -0.4092 + j0.9879$$

$$S_1 = -0.9879 + j0.4092$$

$$S_2 = -0.9879 - j0.4092$$

$$S_3 = -0.4092 - j0.9879$$

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

3

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

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

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

$\sigma_0 = -0.1049$ $\sigma_1 = -0.2532$

$\sigma_2 = -0.2532$ $\sigma_3 = -0.1049$

$\Omega_0 = 0.9580$ $\Omega_1 = 0.3968$

$\Omega_2 = -0.3968$ $\Omega_3 = -0.9580$

$$b_0 = \frac{1}{\sqrt{1+\varepsilon^2}} = 0.7943$$

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

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

$$h(n) = \begin{cases} \dfrac{\sin\left(\frac{\pi}{4}(n-3)\right)}{\pi(n-3)}, & n \neq 3 \\ 0.25, & n = 3 \end{cases}$$

n	h(n)	w(n)	h'(n)
0	0.075	0	0
1	0.1592	0.25	0.0398
2	0.2251	0.75	0.1688
3	0.25	1	0.25
4	0.2251	0.75	0.1688
5	0.1592	0.25	0.0398
6	0.075	0	0

(4)

5 $\alpha = 3, \; N = 7, \; \omega_c = \frac{\pi}{4}$

$$h(n) = \begin{cases} \dfrac{-\sin\left(\frac{\pi}{4}(n-3)\right)}{\pi(n-3)}, & n \neq 3 \\ 0.75, & n = 3 \end{cases}$$

n	h(n)	w(n)	h'(n)
0	−0.075	0.08	−0.006
1	−0.1592	0.31	−0.0493
2	−0.2251	0.77	−0.1733
3	0.75	1	0.75
4	−0.2251	0.77	−0.1733
5	−0.1592	0.31	−0.0493
6	−0.075	0.08	−0.006