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PESIT Bangalore South Campus

Hosur road, 1km before Electronic City, Bengaluru -100

Department of Electronics and Communication

INTERNAL ASSESSMENT TEST 2

Date : 03-04-2017		Marks: **50**
Subject & Code : **Modern DSP(14ESP423)**		Sec : M Tech SP 4th Sem
Name of faculty : **Prof. B. Sireesha**		Time : 8.30 -10.00 AM

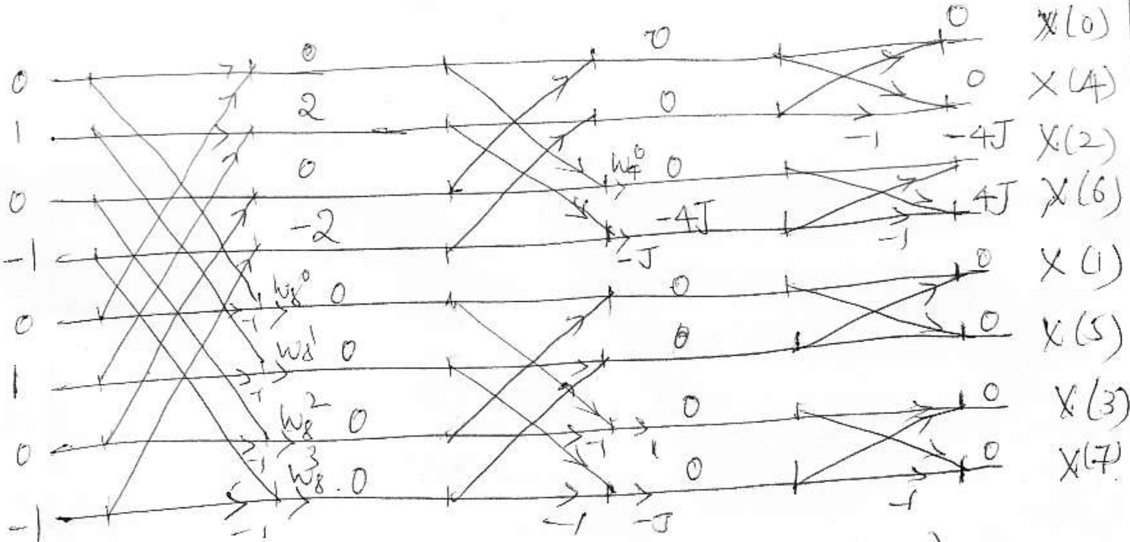
Q.No	Note: Answer FIVE full questions	Marks
1	Derive the expression for calculation of poles using Chebyshev approximation. Obtain the expression for calculating order if gains are in dB.	10
2	Design a digital Chebyshev filter to meet the following design specifications: 1dB cut off at 100π rad/sec, Stop band attenuation of 35dB or greater 1000π rad/sec,Sampling rate 2000 samples/sec,use Bilinear transformation technique.	10
3	Determine 8-point DFT of a continuous time signal $x(t) = \sin(2\pi f t)$ with $f = 50Hz$. Use DIF-FFT algorithm. Let $F_s = 200\ Hz$.	10
4	Design a digital bandpass Butterworth filter with the specifications. Sampling frequency Fs=8KHz,passband attenuation of 2dB at 800Hz and 1000Hz,stopband attenuation of 20dB or more, below 400Hz and above 2000 Hz.	10
5	Design a low-pass FIR filter with the following specifications: Stop band edge 30 rad/sec, Pass band edge 20 rad/sec, Stop band attenuation ≥ 44dB, Pass band ripple ≤ 0.1dB, Sampling frequency 100 rad/sec using Kaiser window.	10
6	Determine filter coefficients of a linear phase low pass FIR filter with Wc=π/4 for N=7 using frequency sampling technique. Determine the frequency response.	10

1)	Sec 10.3.4 of Digital Signal processing — John.G. proakis, Dimitris. G. Manolakis.	10M
2)	$\alpha_p = -1\,dB \quad \alpha_s = -35\,dB$ $\Omega_p = 100\pi$ rad/sec $\quad \Omega_s = 1000\pi$ rad/sec $F_s = 2000$ samples/sec. $W_p = \Omega_p T = 0.05\pi$ rad $W_s = \Omega_s T = 0.5\pi$ rad $\Omega_p' = \frac{2}{T}\tan\frac{W_p}{2} = 314.807$ rad/sec $\Omega_s' = \frac{2}{T}\tan\frac{W_s}{2} = 4000$ rad/sec $N = \cosh^{-1}\left(\sqrt{\frac{10^{-0.1\alpha_s}-1}{10^{-0.1\alpha_p}-1}}\right) / \cosh^{-1}\left(\frac{\Omega_s'}{\Omega_p'}\right) = 1.669 \simeq 2$ $\varepsilon = \sqrt{10^{-0.1\alpha_p}-1} = 0.509$ $\theta = \frac{1}{N}\sinh^{-1}\left(\frac{1}{\varepsilon}\right) = 0.714$ $a = \Omega_p' \sinh\theta = 244.36 \quad b = \Omega_p' \cosh\theta = 398.518$ $\phi_1 = \frac{3\pi}{4} \quad \phi_2 = \frac{5\pi}{4}$ $S_1 = -172.79 + J\,281.79$ $S_2 = -172.79 - J\,281.79$ den. of $H(S) = (S+172.79)^2 + (281.79)^2$ Num of $H(S) = $ den of $H(S)\vert_{s=0} / \sqrt{1+\varepsilon^2}$ $= 97.123 \times 10^3$ $H(S) = \frac{97.123 \times 10^3}{(S^2 + 345.58S + 109.26\times 10^3)}$ $H(Z) = H(S)\Big\vert_{S = \frac{2}{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)} = \frac{1+2z^{-1}+z^{-2}}{1800.07 + 151.65z^{-1} - 327.22z^{-2}}$	5M 5M

3) $x(t) = \sin(2\pi f t)$

$x(n) = \sin\left(\frac{2\pi \times 50 \times n}{200}\right) = \sin\left(\frac{n\pi}{2}\right)$

$= \{0, 1, 0, -1, 0, 1, 0, -1\}$ 2M



8M

$X(k) = \{0, 0, -4J, 0, 0, 0, 4J, 0\}$

4) $F_s = 8\,kHz$ $\alpha_p = -2dB$ $\alpha_s = -20dB$

$f_u = 1000Hz$ $f_1 = 400Hz$

$f_l = 800Hz$ $f_2 = 2000Hz$

$\omega_1 = \frac{2\pi f_1}{F_s} = 0.1\pi\ rad$ $\omega_2 = 0.5\pi\ rad$

$\omega_l = 0.2\pi\ rad$ $\omega_u = 0.25\pi\ rad$

$\Omega_1' = \omega_1 T = 2534.15\ r/s$

$\Omega_2' = 16k\ rad/sec$

$\Omega_l' = 5198.72\ r/s$

$\Omega_u' = 6627.42\ r/s$ 2M

$A = \frac{-\Omega_1^2 + \Omega_l \Omega_u}{\Omega_1(\Omega_u - \Omega_l)} = 7.6$ $B = \frac{-\Omega_2^2 + \Omega_l \Omega_u}{\Omega_2(\Omega_u - \Omega_l)} = -9.69$

$\Omega_r = \min(|A|, |B|) = 7.6\ rad/s$

$$N = \log\left(\frac{10^{-0.1\alpha_p}-1}{10^{-0.1\alpha_s}-1}\right) \Big/ 2\log\left(\frac{1}{\Omega_r}\right) = 1.26 \simeq 2$$ 3M

$$\Omega_c = \frac{1}{\left(10^{-0.1\alpha_p}-1\right)^{1/2N}} = 1.143$$

for $N=2$: $$H_N(S) = \frac{1}{s^2+\sqrt{2}s+1}$$

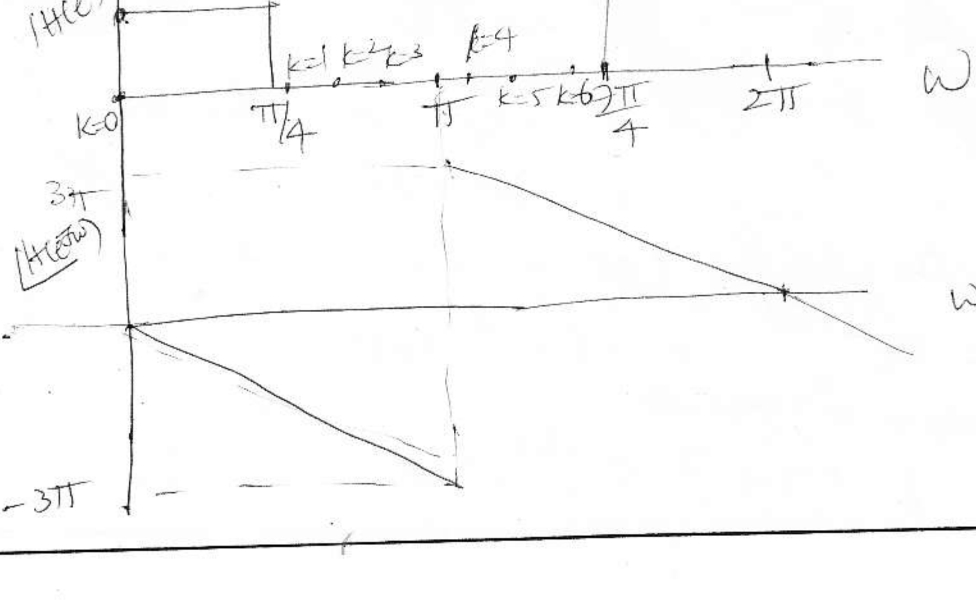
$$H_p(S) = H_N(S)\Big|_{s=\frac{s}{\Omega_c}} = \frac{(1.143)^2}{s^2+1.6175s+(1.143)^2}$$

$$H_d(S) = H_p(s)\Big|_{s=\frac{s^2+\Omega_l'\Omega_u'}{s(\Omega_u'-\Omega_l')}}$$

$$= \frac{2.667\times10^6 s^2}{(s^2+34.45\times10^6)^2 + 2.3\times10^3(s^3+34.45\times10^6 s) + (2.667\times10^6)s^2}$$ 3M

$$H(z) = H_d(S)\Big|_{s=\frac{2}{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)}$$ 2M

6) $H(e^{j\omega}) = e^{-j3\omega} \quad |\omega_c| \le \pi/4$



3M

$\omega_k = \frac{2\pi k}{7}$ $\quad k=0 \Rightarrow \omega = 0$

$k=1 \quad \omega = 0.286\pi$

$k=2 \quad \omega = 0.571\pi$

$k=3 \quad \omega = 0.857\pi$

$k=4 \quad \omega = 1.143\pi$

$k=5 \quad \omega = 1.428\pi$

$k=6 \quad \omega = 1.714\pi$

$|H(k)| = 1, \; k=0$

$\quad 0, \; k = 1,2,3,4,5,6$

$\angle H(k) = -\frac{6\pi}{7} \quad k = 0,1,2,3$

$\quad 6\pi - \frac{6\pi}{7} \quad k = 4,5,6$ 3M

$H(k) = 1 \cdot e^{-j\frac{6\pi}{7}} \quad k=0$

$\quad 0 \quad k = 1,2,3,4,5,6$

$$h(n) = \frac{1}{7}\left[H(0) + \sum_{n=0}^{3} Re\{H(k)e^{j\frac{2\pi}{N}kn}\}\right]$$

$$= \frac{1}{7}(1) \quad n = 0,1,2,3,4,5,6.$$

$$H(e^{j\omega}) = \sum_{n=0}^{6} h(n)e^{-j\omega n}$$

$$= \frac{2}{7}e^{-j3\omega}\left[0.5 + \cos\omega + \cos 2\omega + \cos 3\omega\right]$$ 4M

5) $B.W = \Omega_s - \Omega_p \qquad \Omega_s = 30$ rad/sec

$\Omega_p = 20$ rad/sec

$= 10$ rad/sec $\qquad \alpha_p = -0.1$dB $\quad \alpha_s = -44$ dB

$2\pi f_s = 100$ rad/sec

$\Omega_c = \frac{1}{2}(\Omega_p + \Omega_s)$ (or) $\frac{B.W}{2} + \Omega_p = 25$ rad/sec

$\omega_c = \Omega_c T = \Omega_c \cdot \frac{2\pi}{100} = \frac{\pi}{2}$ rad

If $\alpha_s = -44 \Rightarrow A = 44$ 3M

$\beta = 0.5842(A-21)^{0.4} + 0.07886(A-21)$

$= 3.9524$

$D = \frac{A - 7.95}{14.36}$ for $\alpha_s > 21$

$= 2.566$

$N \geq \frac{2\pi F_s \times D}{B.W} + 1 \geq 26.6 \simeq 27$

$W_K(n) = \frac{I_0\left[\beta\sqrt{1-\left(\frac{2n}{N-1}\right)^2}\right]}{I_0(\beta)}$ $\beta = 3.9524$ 3M

$I_0(\beta) = 10.8468$

$W_K(0) = 1$ $W_K(1) = 0.989$

$W_K(2) = 0.9603$ $W_K(3) = 0.9124$

for LPF $hd(n) = \frac{\sin \omega_c(n-\alpha)}{\pi(n-\alpha)} = \frac{\sin \frac{\pi}{2}(n-27)}{\pi(n-27)}$

$h(n) = hd(n)\, W_K(n)$.

$n=0$ $= 0.5$ 4M

1 $= 0.31479$

2 0

3 -0.0967