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PESIT Bangalore South Campus

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

Department of Electronics and Communication

INTERNAL ASSESSMENT TEST 1			
Date	: 27/02/2017		Marks: **40**
Subject & Code	:DSP SYSTEM DESIGN **(14ESP22)**		Specialization :M.Tech SP
Name of faculty	: Neethu P S/Dr. Bajarangbali		Time : 11:30 AM -1:00PM

Note: Answer FIVE full questions, selecting any ONE full question from each part.			**Marks**
		PART 1	
1	**a**	Describe Fourier series method of designing FIR filters?	**6**
	b	Write notes on rectangular window function?	**2**
2	**a**	Design a digital IIR filter to approximate a second order low-pass analogue filter described by following transfer function: $H(s)=\frac{1}{s^2+\sqrt{2}s+1}$ Digital filter should have a cut-off frequency of 6 KHz and a sampling frequency of 20 KHz.	**8**
		PART 2	
3	**a**	Derive the condition in which FIR filters have constant group delay and phase delay.	**5**
	b	Determine the order of the filter. Given the specifications, -2dB passband attenuation at a frequency of 20 rad/sec and at least -10dB stopband attenuation at 30 rad/s.	**3**
4	**a**	Design an ideal LPF with a frequency response $H_d(e^{j\omega})=1 \quad for\ -\pi/2\le\omega\le\pi/2$; $=0 \quad for\ \pi/2\le\lvert\omega\rvert\le\pi$ Find the values of *h(n)* for *N*=11. Find *H(z)*	**6**
	b	What is causal filter?	**2**
		PART 3	
5	**a**	What are the constraints on the zero locations of linear phase FIR filter?	**5**
	b	Write notes on properties of FIR filters?	**3**
6	**a**	Describe the BLT method for deriving a digital filter from its counterpart analogue filter.	**6**
	b	Apply BLT to $H(S)=\frac{2}{(S+1)(S+2)}$ with T=1 sec and find *H(z)*.	**2**
		PART 4	
7	**a**	Explain the importance of DSP processors with their applications.	**6**
	b	Mention the typical DSP algorithms.	**2**

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8	**a**	With neat diagram explain the architecture of TMS320C6000 processor.	**8**
		PART 5	
9	**a**	Explain the CPU data cross paths and address cross paths with reference to TMS320C6000 processor.	**8**
10	**a**	Write a note on the following a) DSP in ASIC b) The TMS320 family evolution and c) Memory with reference to C62XX /C67XX devices.	**6**
	b	With neat diagram explain the operation of data memory access.	**2**

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SCHEME AND SOLUTION

1st INTERNAL TEST

(1)

Faculty: NEETHU PS **Semester:** M.Tech 2nd sem.

Subject: DSP SD **Sub. Code:** 14EBP22

Q.No.	Questions and its answers Marks	Marks
1	Describe Fourier Series method of designing FIR filters?	6
	Desired Freq Response of FIR filter can be represented by Fourier Series $$Hd(e^{j\omega}) = \sum_{n=-\infty}^{\infty} hd(n) e^{-j\omega n}.$$ $$hd(n) = \frac{1}{2\pi}\int_{-\pi}^{\pi} Hd(e^{j\omega}) e^{j\omega n} d\omega$$	2
	The z transform of the sequence is given by $$H(z) = \sum_{n=-\infty}^{\infty} hd(n) z^{-n}$$ Above eqn represents a noncausal digital filter of infinite duration. To get an FIR filter transfer fn the series can be truncated by $$h(n) = hd(n) \text{ for } \lvert n\rvert \le \frac{N-1}{2}.$$ $$= 0 \text{ otherwise}$$ $$H(z) = \sum_{n=-(\frac{N-1}{2})}^{\frac{N-1}{2}} h(n) z^{-n} = h\left(\frac{N-1}{2}\right) z^{-(\frac{N-1}{2})} + \cdots h(1) z^{-1}$$ $$+ h(0) + h(-1) z + h(-2) z^2 + \cdots h\left[-\left(\frac{N-1}{2}\right)\right] z^{(N-1)/2}.$$	2

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

For a symmetrical impulse response having symmetry at $n = 0$ $\quad h(-n) = h(n)$

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

The above transfer fn is not physically realizable

It can be brought out by multiplying by $z^{-(N-1)/2}$

where $\frac{N-1}{2}$ is delay in samples.

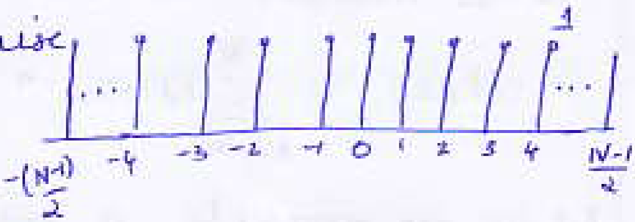
$$H'(z) = z^{-(N-1)/2} H(z)$$

1 b. Write notes on rectangular function

Rectangular window sequence is given by

$w_R(n) = 1$ for $-(N-1)/2 \le n \le (N-1)/2$ 2

$= 0$ otherwise



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Faculty: **Semester:**

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Q.No.	Questions and its answers Marks	
2	Design a digital IIR filter to approximate a second order low-pass analog filter $H(s) = \frac{1}{s^2+\sqrt{2}s+1}$. Digital filter should have a cut-off freq 6KHz & f_{sap} = 20KHz	8
	$H(s) = \frac{1}{s^2+\sqrt{2}s+1}$ / $s = \frac{2}{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$	1
	$\Omega_c = \frac{2}{T_s}\tan\left(\frac{\omega_c T_s}{2}\right)$ cut off freq digital $= (\omega_c)$	
	~~Ste~~ denormalize the analoge filter by ω_c $s \rightarrow s/\omega_c$ Analog cut off freq Ωc	
	$s = \frac{2}{T_s}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$ $\frac{s}{\Omega c} = \frac{1}{\tan(\omega_c T_s)}\frac{1-z^{-1}}{1+z^{-1}}$	3
	$= \frac{1}{a}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$ $a = \tan(\omega_c T_s)$	
	$= \frac{1}{\frac{1}{a^2}\left(\frac{z-1}{z+1}\right)^2+\frac{\sqrt{2}}{a}\left(\frac{z-1}{z+1}\right)+1}$	
	$= \frac{a^2(z^2+2z+1)}{(z^2-2z+1)+\sqrt{2}a(z^2-1)+a^2(z^2+2z+1)}$	

$$a^2 \cdot \frac{z^2+2z+1}{z^2(1+\sqrt{2}a+a^2)+z(2a^2-2)+(1+a^2-\sqrt{2}a)}$$

$$H(z) = \frac{1+2z^{-1}+z^{-2}}{\left(\frac{1+\sqrt{2}a+a^2}{a^2}\right)+\frac{2(a^2-1)}{a^2}+\frac{(1+a^2-\sqrt{2}a)}{a^2}z^{-2}}$$

$$= \frac{b_0+b_1z^{-1}+b_2z^{-2}}{1+a_1z^{-1}+a_2z^{-2}}.$$

4p

$$a = \tan\left(\frac{\pi f_p}{f_s}\right) = 1.376382.$$

$$b_0 = \frac{a^2}{1+\sqrt{2}a+a^2}. \qquad b_1 = 2b_0 \qquad b_2 = b_0$$

$$a_1 = \frac{2(a^2-1)}{(1+\sqrt{2}a+a^2)} \qquad a_2 = \frac{1+a^2-\sqrt{2}a}{1+a^2+\sqrt{2}a}.$$

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Faculty: **Semester:**

Subject: **Sub. Code:**

Q.No.	Questions and its answers Marks	Marks
3 a	Derive the condition in which FIR filters have Constant group delay & phase delay.	5M
	$H(z) = \sum_{n=0}^{N-1} h(n) z^{-n}$ — (1)	
	$H(e^{j\omega}) = \sum_{n=0}^{N-1} h(n) e^{-j\omega n}$ — (2)	
	$H(e^{j\omega}) = \pm \lvert H(e^{j\omega}) \rvert e^{j\theta(\omega)}$ — (3)	2
	$\tau_p = \frac{-\theta(\omega)}{\omega}$ $\tau_g = \frac{-d\theta(\omega)}{d\omega}$ — (4)	
	For FIR filter with linear phase we can define	
	$\theta(\omega) = -\alpha\omega$ $-\pi \le \omega \le \pi$ α is const phase delay in sample	
	$\tau_p = \tau_g = \alpha$ α is independent of frequency	
	$\sum_{n=0}^{N-1} h(n) e^{-j\omega n} = \pm \lvert H(e^{j\omega}) \rvert e^{j\theta(\omega)}$ — (5)	2
	$\sum_{n=0}^{N-1} h(n) \cos\omega n = \pm \lvert H(e^{j\omega}) \rvert \cos\theta(\omega)$ — (6)	
	$-\sum_{n=0}^{N-1} h(n) \sin\omega n = \pm \lvert H(e^{j\omega}) \rvert \sin\theta(\omega)$ — (7)	
	(6)/(7) $\frac{\sum_{n=0}^{N-1} h(n) \sin\omega n}{\sum_{n=0}^{N-1} h(n) \cos\omega n} = \frac{\sin\alpha\omega}{\cos\alpha\omega}$	

$$\sum_{n=0}^{N-1} h(n)\sin(\alpha-n)\omega = 0$$ this eqn is zero if

$$h(n) = h(N-1-n) \quad \& \quad \alpha = \frac{N-1}{2}.$$ 1

3b. Determine the order of the filter 3

$\alpha_p = 2dB \qquad \Omega_p = 20rad/s$

$\alpha_s = 10dB \qquad \Omega_s = 30rad/s$

$$N \geq \frac{\log\sqrt{\frac{10^{0.1\alpha_s}-1}{10^{0.1\alpha_p}-1}}}{\log\frac{\Omega_s}{\Omega_p}} \geq \frac{\log\sqrt{\frac{10-1}{10^{2}-1}}}{\log\frac{30}{20}}$$ 2

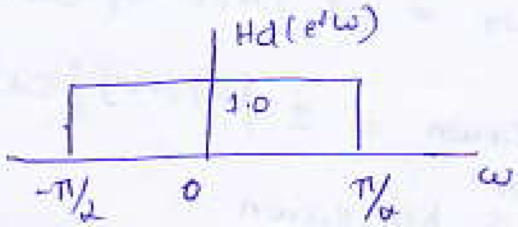
≥ 3.37 Rounding N to next higher integer we get $N = 4$ 1

4a. Design an ideal LPF filter with freq response 6

$$H_d(e^{j\omega}) = 1 \quad \text{for } -\pi/2 \leq \omega \leq \pi/2.$$
$$= 0 \quad \text{for } \pi/2 \; |\omega| \leq \pi.$$

find values of $h(n)$ for $N = 11$ find $H(z)$.

$H_d(e^{j\omega}) = 1$ 3



$$h_d(n) = \frac{1}{2\pi}\int_{-\pi}^{\pi} H_d(e^{j\omega})e^{j\omega n}\,d\omega$$

$$= \frac{1}{2\pi j n} e^{j\omega n}\Big|_{-\pi/2}^{\pi/2}$$

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Faculty: **Semester:**

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Q.No.	Questions and its answers Marks	
a	$\frac{1}{\pi n 2j}\left[e^{j\pi n/2} - e^{-j\pi n/2}\right]$	
	$= \frac{\sin \pi n/2}{\pi n} \quad -\infty \le n \le \infty$	
	Truncating to 11 samples	
	$h(n) = \frac{\sin \frac{\pi}{2} n}{\pi n}$ for $\lvert n \rvert \le 5$	3
	$h(0) = \lim_{n \to 0} \frac{\sin \pi/2\, n}{\pi n} = \frac{1}{2}$	
	$h(1) = h(-1) = \frac{\sin \pi/2}{\pi} = 0.3183$	
	$h(2) = h(-2) = \frac{\sin \pi}{2\pi} = 0$	
	$h(3) = h(-3) = -0.106$	
	$h(4) = h(-4) = 0$	
	$h(5) = h(-5) = \frac{\sin 5\pi/2}{5\pi} = 0.06366$	
	The transfer function of realizable filter is	
	$H'(z) = H(z)\, z^{-(N-1)/2}$	
	$= z^{-5}\left[0.5 + 0.3183(z^{1} + z^{-1}) - 0.106(z^{3} + z^{-3}) + 0.06366(z^{5} + z^{-5})\right]$	

4b What is causal filter

a causal filter is a filter with impulse response $h(n) = 0$ for $n < 0$

For causal filter o/p does not depends ~~only~~ on ~~present &~~ future o/p.

2

5a. What are constraints on zero location of linear phase FIR filter

5

$$H(z) = \sum_{n=0}^{N-1} h(n) z^{-n}$$

If $z_0 \neq 0$ is a finite zero of $H(z)$ then

then $H(z)\big|_{z=z_0} = H(z_0) = \sum_{n=0}^{N-1} h(n) z_0^{-n} = 0$

$= h(0) + h(1) z_0^{-1} + \cdots h(N-1) z_0^{-(N-1)} = 0$

3

For a linear phase filter $h(n) = h(N-1-n)$

$H(z)\big|_{z=z_0} = h(N-1) + h(N-2) z_0^{-1} + \cdots h(1) z_0^{-(N-2)}$

$+ h(0) z_0^{-(N-1)} = 0$

$= z^{-(N-1)} \left[h(N-1) z_0^{(N-1)} + h(N-2) z_0^{N-2} + \cdots \right.$

$\left. h(1) z_0^{1} + h(0) \right] = 0$.

$= z^{-(N-1)} \sum_{n=0}^{N-1} h(n) z_0^{n} = 0$

$H(z_0) = z^{-(N-1)} \sum_{n=0}^{N-1} h(n) (z_0^{-1})^{-n} = z^{-(N-1)} H(z_0) = 0$

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Q.No.	Questions and its answers Marks	
2	$H(z_0) = z^{-(N-1)} \sum_{n=0}^{N-1} h(n)(z_0^{-1})^{-n} = z^{-(N-1)} H(z_0^{-1}) = 0$ $H(z_0) = H(z_0^{-1}) = 0$ z_0 is a zero of $H(z)$ & z_0^{-1} is also a zero zeros of linear phase FIR filter lie on a OC.	2
5b	Properties of FIR filter 1. FIR filter are stable 2. FIR filter with linear phase can easily be designed 3. FIR filters can be realized in both recursive & nonrecursive structures. 1/2 Mark per point 4. FIR filters are free of limit cycle oscillations when implemented on finite world length digital S/m 5. The implementation of narrow transition band FIR filters are very costly 6. Memory requirement & execution time is very high	3

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Q.No	Questions and its answers Marks	
6a.	Describe BLT Method for deriving a digital filter from the counterpart analogue filter	6
	Consider an analog linear filter with s/m fn.	
	$H(s) = \frac{b}{s+a}$ $\frac{Y(s)}{X(s)} = \frac{b}{s+a}$ — ①	
	$sY(s) + aY(s) = bX(s)$ — ②	2
	$\frac{dy(t)}{dt} + a y(t) = b x(t)$ — ③	
	y(t) can be approximated by trapezoidal formula.	
	$y(t) = \int_{t_0}^{t} y'(\tau) d\tau + y(t_0)$ — ④	
	The approximation of integral by trapezoidal formula. $y(t) = \int_{t_0}^{t} y'(\tau) d\tau + y(t_0)$	2
	$y(nT) = \frac{T}{2}\left[y'(nT) + y'(nT-T)\right] + y(nT-T)$ — ⑤	
	$y'(nT) = -ay(nT) + bx(nT)$ — ⑥	

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Q.No.	Questions and its answers Marks	
	Substituting (5) in (6)	
	$\left(1+\frac{aT}{2}\right) Y(z) - \left(1-\frac{aT}{2}\right) z^{-1} Y(z)$	
	$= \frac{bT}{2}\left[1+z^{-1}\right] X(z) \quad — (7)$	
	S/m fn of digital filter is	
	$H(z) = \frac{Y(z)}{X(z)} = \frac{\frac{bT}{2}(1+z^{-1})}{1+\frac{aT}{2} - \left(1-\frac{aT}{2}\right) z^{-1}} \quad — (8)$	
	$= \frac{\frac{bT}{2}(1+z^{-1})}{(1-z^{-1}) + \frac{aT}{2}(1+z^{-1})} \quad — (9)$	2
	$H(z) = \frac{b}{\frac{2}{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right) + a} \quad — (10)$	
	$S = \frac{2}{T}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)$ The relationship b/w	
	S & z is known as Bilinear transformation	

6b. Apply BLT to $H(s) = \frac{2}{(s+1)(s+2)}$ with $T = 1$ sec & find $H(z)$

$$s = \frac{2}{T}\left[\frac{1-z^{-1}}{1+z^{-1}}\right]$$

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

2

given $T = 1$ sec. $H(z) = \frac{2}{\left\{2\left(\frac{1-z^{-1}}{1+z^{-1}}\right)+1\right\}\left\{2\left(\frac{1-z^{-1}}{1+z^{-1}}\right)+2\right\}}$

$$= \frac{2(1+z^{-1})^2}{(3-z^{-1})(4)} = \frac{0.166(1+z^{-1})^2}{1-0.33z^{-1}}$$