Modified

CBCS SCHEME

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18EC52

Fifth Semester B.E. Degree Examination, Feb./Mar.2022
Digital Signal Processing

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Prove that the sampling of DTFT of a sequence x(n) result in N-point DFT with a neat diagram. **(10 Marks)**

b. Find the 4-point DFT of the sequence $x(n) = \{1, 0, 0, 1\}$ using matrix method and verify the answer by taking the 4-point IDFT of the result. **(10 Marks)**

OR

2 a. Derive the circular Time shift property. **(06 Marks)**

b. Compute the circular convolution of the following sequences using DFT and IDFT method $x_1(n) = \{1, 2, 3, 4\}$ and $x_2(n) = \{4, 3, 2, 1\}$. **(09 Marks)**

c. If $W(n) = \frac{1}{2} + \frac{1}{2}\cos\left[\frac{2\pi}{N}\left(n - \frac{N}{2}\right)\right]$, what is the DFT of the window sequence $y(n) = x(n).w(n)$? Relate the answer in terms of X(K). **(05 Marks)**

Module-2

3 a. Find the output y(n) of a filter whose impulse response is h(n) = {1, 1, 1} and the input signal $x(n) = \{3, -1, 0, 1, 3, 2, 0, 1, 2, 1\}$ using overlap-add method. Assume the length of each block N is 6. **(10 Marks)**

b. What do you mean by computational complexity? Compare the direct computation and FFT algorithms. In the direct computation of 32-point DFT of x(n), How many
   - (i) Complex multiplications
   - (ii) Complex additions.
   - (iii) Real multiplications.
   - (iv) Real additions and
   - (v) Trigonometric function evaluations are required. **(10 Marks)**

OR

4 a. Develop 8-point DIT-FFT Radix-2 algorithm and draw the signal flow graph. **(10 Marks)**

b. Given $x(n) = n + 1$ for $0 \le n \le 7$. Find X(K) using DIF-FFT algorithm. **(10 Marks)**

Module-3

5 a. What are the different design techniques available for the FIR filters? Explain Gibbs phenomenon. Explain the four window techniques for the designing of FIR filters. **(10 Marks)**

b. A low pass filter is to be designed with the following desired frequency response,

$$H_d(e^{j\omega}) = \begin{cases} e^{-j3\omega} & , \text{for } -\frac{3\pi}{4} \le \omega \le \frac{3\pi}{4} \\ 0 & , \frac{3\pi}{4} \le \omega \le \pi \end{cases}$$

Determine $H(e^{j\omega})$ for M = 7 using Hamming window. **(10 Marks)**

OR

6 a. A FIR filter is given by,

$$y(n) = x(n) + \frac{2}{5}x(n-1) + \frac{3}{4}x(n-2) + \frac{1}{3}x(n-3)$$

Draw the lattice structure. **(10 Marks)**

b. Based on the frequency-sampling method, determine the coefficients of a linear-phase FIR filter of length M = 15 which has a symmetric unit sample response and a frequency response that satisfies the conditions.

$$H\left(\frac{2\pi}{15}K\right) = 1; \quad K = 0, 1, 2, 3$$
$$= 0.4; \quad K = 4$$
$$= 0 \; ; \quad K = 5, 6, 7$$

(10 Marks)

Module-4

7 a. The normalized transfer function of a 2nd order Butterworth filter is given by,

$$H_2(S) = \frac{1}{S^2 + 1.414S + 1}$$

Convert the analog filter into digital filter with cut-off frequency of 0.5π rad/sec using bilinear transformation. Assume T = 1 sec. **(10 Marks)**

b. A filter is given by the difference equation $y(n) - \frac{1}{4}y(n-1) + \frac{1}{8}y(n-2) = x(n) + \frac{1}{2}x(n-2)$.

Draw direct form – I and direct form – II realizations. Also obtain the transfer function of the filter. **(10 Marks)**

OR

8 a. Derive mapping function used in transforming analog filter to digital filter by bilinear transformation, preserves the frequency selectivity and stability properties of analog filter. **(10 Marks)**

b. Design an IIR digital Butterworth filter that when used in the analog to digital with digital to analog will satisfy the following equivalent specification.
   (i) Low pass filter with -1 dB cut off 100 π rad/sec.
   (ii) Stop band attenuation of 35 dB at 1000 π rad/sec.
   (iii) Monotonic in stop band and pass band.
   (iv) Sampling rate of 2000 rad/sec.
   (v) Use bilinear transformation. **(10 Marks)**

Module-5

9 a. With the block diagram, explain Digital Signal processors based on the Harvard architecture. **(10 Marks)**

b. Discuss briefly the following special digital signal processor hardware units:
   (i) Multiplier and Accumulator (MAC) unit.
   (ii) Shifters.
   (iii) Address Generators. **(10 Marks)**

OR

10 a. Discuss the following IEE Floating-point formats:
   (i) Single precision format.
   (ii) Double precision format. **(10 Marks)**

b. With the diagram, explain the basic architecture of TMS320C54X family processor. **(10 Marks)**

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Comments from BoE of ECE Board

"Manjunatha P" <manjup.jnnce@gmail.com>
To: boe@vtu.ac.in

March 3, 2022 10:35 AM

Comments from BoE of ECE Board for the following subjects towards Scheme and solution:

Dear Sir,

#	Code	Subject Name	Comments from BoE ECE/ETE
1.	18EC731	Real Time Systems	As per the scrutiny from BoE members, there is no correction
2.	18EC732	Satellite Communication	As per the scrutiny from BoE members, there is no correction
3.	18EC733	Digital Image Processing	As per the scrutiny from BoE members, there is no correction.
4.	18EC734	DSP Algorithms and Architecture	As per the scrutiny from BoE members, there is no correction
5.	18EC52	Digital Signal Processing	There is no issue in Q7 a) In Q8 b) Sampling frequency assumed to be in Hz, there is a typo error, it's unit is given as rad/sec
6.	18EC53	Principles of Communication Systems	As per the scrutiny from BoE members, there is no correction

Hence the same may be considered for the further process

With regards

Dr. Manjunatha
Chairman BoE for ECE
Professor & Dean Academics JNN College of Engineering

Shimoga

Kindly download the attachment

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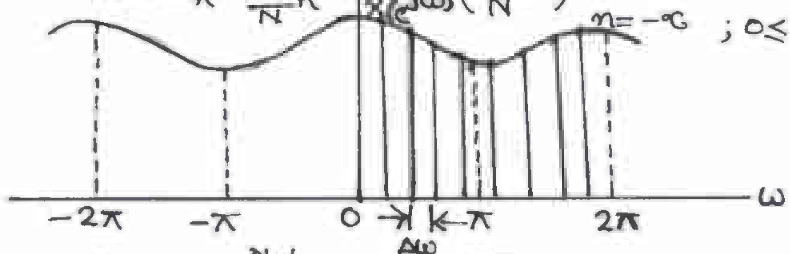
Signature of Scrutinizer

Scheme & Solutions

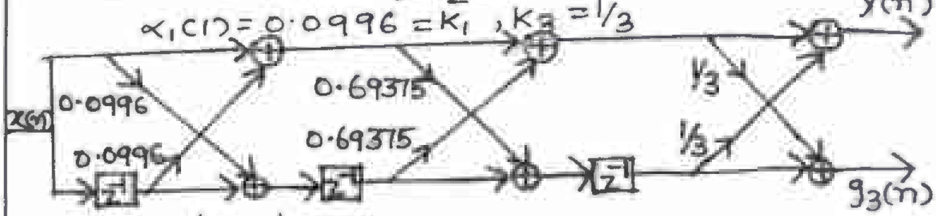
Subject Title : Digital Signal processing **Subject Code :** 18EC52

Question Number	Solution	Marks Allocated
1. (a)	Consider a non-periodic finite energy discrete time signal $x(n)$. Its Fourier transform is given by	
	$X(\omega)=X(e^{j\omega})=\sum_{n=-\infty}^{\infty}x(n)e^{-j\omega n}$ — (1)	
	$X(e^{j\omega})\Big\rvert_{\omega=\omega_K=\frac{2\pi}{N}K}=X\left(\frac{2\pi}{N}K\right)=\sum_{n=-\infty}^{\infty}x(n)\cdot e^{-j\frac{2\pi}{N}Kn}$; $0\leq K\leq N-1$	
		1M
	$X\left(\frac{2\pi}{N}K\right)=\sum_{n=0}^{N-1}x_p(n)e^{-j\frac{2\pi}{N}Kn}$	
	$x_p(n)=\frac{1}{N}\sum_{K=0}^{N-1}X\left(\frac{2\pi}{N}K\right)e^{j\frac{2\pi}{N}Kn}$, $0\leq n\leq N-1$	3M
	Derivation → DFT	3M
	→ IDFT	3M
	Explanation →	10M
1. (b)	We have, $X_N=W_N x_N$, Since $N=4$	1M
	$\therefore X(K)=\{2,1+j,0,1-j\}$	4M
	$x_N=\frac{1}{N}W_N^{*}X_N$	1M
	$x(n)=\{1,0,0,1\}$	4M
	Hence the result is verified.	10M
2. (a)	Circular Time shift property :	
	If $x(n)\underset{DFT}{\overset{N}{\longleftrightarrow}}X(K)$	1M
	then $x((n-l))_N\underset{DFT}{\overset{N}{\longleftrightarrow}}X(K)e^{-j\frac{2\pi}{N}Kl}=W_N^{Kl}X(K)$	
	Derivation :	
	$DFT\{x((n-l))_N\}=X(K)e^{-j\frac{2\pi}{N}Kl}=W_N^{Kl}X(K)$	5M
		6M
2. (b)	$X(K)=\sum_{n=0}^{N-1}x(n)e^{-j\frac{2\pi}{N}Kn}$, $0\leq K\leq N-1$	1M
	$X_1(K)=1+2\cdot e^{-j\frac{\pi}{2}K}+3\cdot e^{-J\pi K}+4\cdot e^{-J\frac{\pi}{2}K3}$	
	$X_1(K)=\{10,-2+2J,-2,-2-2J\}$ — (1)	2M
	$X_2(K)=\{10,2-2J,2,2+2J\}$ — (2)	2M
	$Y(K)=X_1(K)\cdot X_2(K)$ — (3)	1M

Subject Title : DSP Subject Code : 18EC52

Question Number	Solution	Marks Allocated
	$Y(K) = \{100, 8, -4, -8\}$ — (4)	
	Now take IDFT of $Y(K)$, $y(n) = \frac{1}{N}\sum_{K=0}^{N-1} Y(K) \cdot e^{\frac{J2\pi}{N}K \cdot n}$, $0 \le n \le N-1$	1M
	$y(n) = x_1(n) ④ \cdot x_2(n) = \{24, 22, 24, 30\}$	2M
		9M
2.(c)	$y(n) = x(n) \cdot \omega(n)$	
	By simplifying $\omega(n)$, it becomes	
	$\omega(n) = \frac{1}{2} - \frac{1}{2}\cos\frac{2\pi}{N} n$	2
	$y(n) = \frac{x(n)}{2} - \frac{1}{4}\left[x(n) \cdot e^{J\frac{2\pi}{N} \cdot n} + x(n) \cdot e^{-J\frac{2\pi}{N} \cdot n}\right]$ — (1)	
	$y(n) = \frac{x(n)}{2} - \frac{1}{4}\left[x(n) \cdot W_N^{-n} + x(n) \cdot W_N^{n}\right]$ — (2)	
	using the formula of DFT property (CFS)	
	$x(n) \cdot e^{\frac{J2\pi}{N} ln} \xleftrightarrow[DFT]{N} X((K-l))_N$	1
	$Y(K) = \frac{X(K)}{2} - \frac{1}{4}\left[X((K-1))_N + X((K+1))_N\right]$	2
		5
3.(a)	$x(n) = \{3, -1, 0, 1, 3, 2, 0, 1, 2, 1\}$ $\therefore L_S = 10$	
	$h(n) = \{1, 1, 1\}$ $\therefore M = 3$	1M
	$N = L + M - 1 = 6$ $\therefore L = 4$	2M
	$y_1(n) = x_1(n) ⑥ h(n) = \{3, 2, 2, 0, 1, 1\}$	2M
	$y_2(n) = x_2(n) ⑥ h(n) = \{3, 5, 5, 3, 1, 1\}$	2M
	$y_3(n) = x_3(n) ⑥ h(n) = \{2, 3, 3, 1, 0, 0\}$	
	$\therefore y(n) = \{3, 2, 2, 0, 4, 6, 5, 3, 3, 4, 3, 1\}$	3M
		10M
3.(b)	Explanation of computational complexity	1M
	comparison of Direct computation and FFT algorithm (atleast 4 points)	4M
	$N = 32$	
	complex multiplications $= N^2 = (32)^2 = 1024$	1M
	complex Additions $= N^2 - N = (32)^2 - 32 = 992$	1M
	Real Multiplications $= 4N^2 = 4(32)^2 = 4096$	1M
	Real Additions $= 4N^2 - 2N = 4(32)^2 - 2(32) = 4032$	1M
	No. of trignometric evaluations $= 2N^2 = 2(32)^2 = 2048$	1M
		10M
4.(a)	The N-point DFT is decimated into two $\frac{N}{2}$-point DFTs, then each $\frac{N}{2}$-point DFT is decimated into two $\frac{N}{4}$-point DFTs [Equations and explanations for the above two]	3M 3M
	Finally reduced flow graph for 8-point DIT-FFT algorithm	4M
		10M
4.(b)	$x(n) = \{1, 2, 3, 4, 5, 6, 7, 8\}$	1M
	The DIF-FFT algorithm for N=8 (Figure)	4M
	$\therefore X(K) = \{36, -4+J9.656, -4+J4, -4+J1.656, -4, -4-J1.656, -4-J4, -4-J9.656\}$	5M
	(Explanation and calculation)	10M

Subject Title : DSP   Subject Code : 18EC52

Question Number	Solution	Marks Allocated
5.(a)	Different design techniques Gibbs phenomenon Explanation of four window techniques (4x2M) [Formulae along with Figure]	1M 1M 8M 10M
5.(b)	The filter coefficients are given by $hd(n) = \frac{1}{2\pi}\int_{-\pi}^{\pi} H_d(e^{J\omega})e^{J\omega n}d\omega$ $h_d(n) = \frac{\sin 3\pi(n-3)/4}{\pi(n-3)}$, $n \neq 3$ and $h_d(3) = \frac{3}{4}$ The filter coefficients are, $hd(0) = 0.0750$, $h_d(1) = 0.1592$, $hd(2) = 0.225$ $hd(3) = 0.75$, $hd(4) = 0.2251$, $hd(5) = 0.1592$ $hd(6) = 0.0750$ The hamming window function is, $w(n) = \begin{cases} 0.54 - 0.46\cos\frac{2\pi n}{M-1}, & 0 \le n \le M-1 \\ 0 & \text{otherwise} \end{cases}$ The filter coefficients of the resultant filter will be then $h(n) = h_d(n) \cdot w(n)$, $n = 0,1,2,3,4,5,6$ $\therefore h(0) = 0.006$, $h(1) = -0.0494$, $h(2) = 0.1733$, $h(3) = 0.75$, $h(4) = 0.1733$, $h(5) = -0.0494$ and $h(6) = 0.006$ The frequency response is given by $H(e^{J\omega}) = \sum_{n=0}^{6} h(n) \cdot e^{-J\omega n}$ $= e^{-J3\omega}[0.75 + 0.3466\cos\omega - 0.0988\cos 2\omega + 0.012\cos\omega]$	1M 2M 1M 1M 2M 3M 10M
6.(a)	Given $y(n) = x(n) + \frac{2}{5}x(n-1) + \frac{3}{4}x(n-2) + \frac{1}{3}x(n-3)$ $\therefore m = 3$ we have $\alpha_3(0) = 1$; $\alpha_3(1) = \frac{2}{5}$; $\alpha_3(2) = \frac{3}{4}$ and $\alpha_3(3) = K_3 = \frac{1}{3}$ Also $\alpha_{m-1}(K) = \frac{\alpha_m(K) - \alpha_m(m)\alpha_m(m-K)}{1-\alpha_m^2(m)}$ $\alpha_2(1) = 0.16875$, $\alpha_2(2) = 0.69375 = K_2$ $\alpha_1(1) = 0.0996 = K_1$, $K_3 = 1/3$  Lattice structure	1M 7M 2M 10M
6.(b)	Figure $\theta(K) = -\frac{14}{15}K$; $K = 0,1,---7$ $= -\frac{14\pi}{15}(K-15)$; $K = 8,9,---14$ $H(K) = e^{-J\frac{14\pi}{15}K}$; $K = 0,1,2,3$ $= 0.4\,e^{-J\frac{14\pi}{15}K}$; $K=4$	1M 1M 1M

Question Number	Solution	Marks Allocated
	$= 0 \quad ; \quad 5 \leq K \leq 10$ $= 0.4\, e^{-J\frac{14\pi}{15}(K-15)} \quad ; K = 11$ $= e^{-J\frac{14\pi}{15}(K-15)} \quad ; K = 12, 13, 14$ $h(n) = \frac{1}{M}\left[H(0) + 2\cdot\sum_{K=1}^{M-1/2} Re\{H(K)\cdot e^{J\frac{2\pi}{M}nK}\}\right]$ $\therefore h(n) = \frac{1}{15}\left[1 + 2\cos\frac{2\pi}{15}(n-7) + 2\cos\frac{4\pi}{15}(n-7) + 2\cos\frac{6\pi}{15}(n-7) + 0.8\cos\frac{8\pi}{15}(n-7)\right]$ $h(0) = h(14) = 0.0143$, $h(1) = h(13) = -0.002$, $h(2) = h(12) = 0.04$ $h(3) = h(11) = 0.0122$, $h(4) = h(10) = -0.0913$, $h(5) = h(9) = -0.01817$, $h(6) = h(8) = 0.3132$, $h(7) = 0.520$ The system function is given by $H(z) = \sum_{n=0}^{14} h(n)\, z^{-n}$.	1M 2M 3M 1M 10M
7(a)	Given that digital cut-off frequency $w_c = 0.5\pi$ rad/sec $T = 1$ sec, In bilinear transformation, $\Omega = \frac{2}{T}\tan\frac{\omega}{2}$ $\therefore$ Analog cut-off frequency $\Omega_c = 2$ rad/sec $\therefore$ The transfer function of the analog filter $H_a(s) = H_2(s)\big\|_{s \to \frac{s}{\Omega_c}} = H_2(s)\big\|_{s \to \frac{s}{2}}$ $H_a(s) = \frac{4}{s^2 + 2.828s + 4}$ In Bilinear transformation $s = \frac{2}{T}\cdot\frac{1-z^{-1}}{1+z^{-1}}$ $H(z) = H_a(s)\big\|_{s \to 2\cdot\frac{1-z^{-1}}{1+z^{-1}}}$ $\therefore H(z) = \frac{4 + 8z^{-1} + 4\cdot z^{-2}}{13.656 + 2.344z^{-2}}$	1M 1M 3M 1M 4M 10M
7.(b)	The direct form-1 realization-figure The direct form-II realization - Figure Explanation Taking z-transform on both sides $H(z) = \frac{Y(z)}{X(z)} = \frac{1 + \frac{1}{2}\cdot z^{-2}}{1 - \frac{1}{4}z^{-1} + \frac{1}{8}z^{-2}}$	3M 3M 2M 2M 10M
8 (a).	The bilinear transformation can be related to the trapezoidal formula for numerical integration $\frac{d}{dt} y_a(t) = x_a(t)$ Derivation $H(z) = H_a(s)\|_{s \to \frac{2}{T}\frac{1-z^{-1}}{1+z^{-1}}}$ Explanation - Relation between analog and digital IIR filter poles $s = \frac{2}{T}\cdot\frac{1-z^{-1}}{1+z^{-1}}$ Mapping of s-plane onto the z-plane using BLT Figure -	4M 4M 2M 10M

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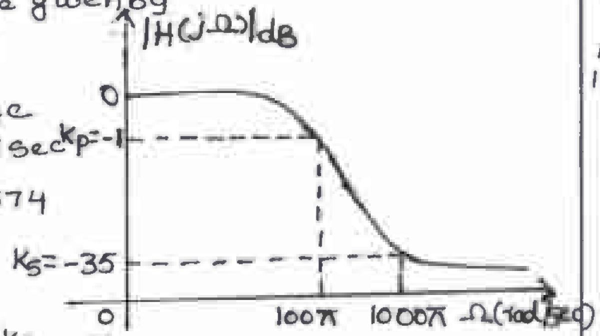
Question Number	Solution	Marks Allocated
8.(b)	$K_p=-1$, $K_s=-35$, $T=\frac{1}{f_s}=0.5$ msec Digital frequencies are given by $\omega_p=\Omega'_pT=0.05\pi$ rad $\omega_s=\Omega'_sT=0.5\pi$ rad preparing the bandedge frequencies using T = 1sec $\Omega_p=\frac{2}{T}\tan\left(\frac{\omega_p}{2}\right)=0.1574$ $\Omega_s=2$  Order of the filter $n=\frac{\log\left[(10^{\frac{-K_p}{10}}-1)/(10^{\frac{-K_s}{10}}-1)\right]}{2\log\left(\frac{\Omega_p}{\Omega_s}\right)}=1.85=2$ $\Omega_c=0.2206$ rad/sec Normalised Transfer function, $H_1(s)=\frac{1}{s^2+\sqrt{2}s+1}$ $H_a(s)=H_2(s)\big\vert_{s\to\frac{s}{\Omega_c}=\frac{s}{0.2206}}=\frac{0.0486}{s^2+0.3119s+0.0486}$ $H(z)=H_a(s)\big\vert_{s\to 2\cdot\frac{1-z^{-1}}{1+z^{-1}}}$, $H(z)=\frac{0.0104(1+z^{-1})^2}{1-1.6913z^{-1}+0.732z^{-2}}$	1M 1M 1M 1M 1M 1M 1M 1M 2M 10M
9. (a).	Explanation of each module → Digital signal processors based on Harvard architecture Figure →	6M 4M 10M
9.(b)	Explanation of Multiplier and Accumulator → Figure Explanation of shifters → Explanation of Address Generators → Figures →	2M 2M 2M 3M 1M 10M
10. (a)	(i) Explanation of IEEE Single precision Floating-point format 31 30 … 23 22 … 0 | S | Exponent | Fraction | $x=(-1)^S\times(1\cdot F)\times2^{E-127}$ (ii) Explanation of IEEE double precision Floating-point Format 31 30 … 20 19 … 0 31 … 0 | S | exponent | Fraction | Fraction | ← odd register → ← even register → $x=(-1)^S\times(1\cdot F)\times2^{E-1023}$	3M 2M 3M 2M 10M
10.(b)	Explanation of Basic Architecture of TMSC320C54x Figure →	6M 4M 10M

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— THE END —