B. INS. & ELEC. ENGINEERING 3RD YEAR 2ND SEMESTER EXAMINATION 2019

DIGITAL SIGNAL PROCESSING

TIME: 3 HOURS **FULL MARKS: 100**

List of Course Outcomes (CO):

CO1: Describe the limitations and advantages of using discrete and digital signals and systems (K2, A1)

CO2: Describe and interpret the mathematical models of discrete time systems (K2, A1)

CO3: Calculate and interpret Fourier transform, Z transform of signals and systems (K2, K3, A1-explain)

CO4: Design and examine digital filters (K3, K4, K5, A3-choose)

Instructions to the Examinees:

- Each module in the question paper matches up with the corresponding CO
- Attempt questions from **ALL** the modules for the attainment of all the COs
- Alternative questions (if any) exist within a module, not across the modules
- Different parts of same question should be answered together

MODULE 1

1.

(a) Illustrate the advantages and limitations of digital signal processing.

(b) Sketch each of the following signals:

i. Continuous time-continuous amplitude

ii. Continuous time-discrete amplitude

iii. Discrete time-continuous amplitude

iv. Discrete time-discrete amplitude

4+6

MODULE 2 *(Answer any two questions)*

2.

(a) Give examples for each of the following systems:

i. Additive but not homogeneous

ii. Linear but not stable

iii. Right sided but not causal

iv. Non-causal but shift-invariant

(b) Show that for a linear system, all zero input produces all zero output. Also prove that the reverse statement is false.

(c) Show that the energy of a real-valued energy signal is equal to the sum of the energies of its even and odd components.

8+4+3

3.

(a) Two discrete-time systems $\mathbb{S}_1$ and $\mathbb{S}_2$ are connected in cascade to form a new system $\mathbb{S}$. Prove or disprove the following statements:

i. If $\mathbb{S}_1$ and $\mathbb{S}_2$ are linear and time invariant, the same holds for $\mathbb{S}$

ii. If $\mathbb{S}$ is found to be stable, then both $\mathbb{S}_1$ and $\mathbb{S}_2$ compulsorily be stable

(b) Find out the causality condition of any LTI system in terms of its impulse response.

(c) Find out the impulse response of the system, described by the difference equation $y(n) = nx(n)$. Will it be possible to comment on the BIBO stability of the system from its impulse response? Explain.

6+5+4

4.

(a) Let $x(n), N_1 \leq n \leq N_2$ and $h(n), M_1 \leq n \leq M_2$ be two finite duration signals.

i. Determine the range $L_1 \leq n \leq L_2$ of their convolution in terms of $N_1,\ N_2,\ M_1,\ M_2$.

ii. Illustrate the validity of your results by computing the convolution of the signals:

$$x(n) = \begin{cases} 1, & -2 \leq n \leq 4 \\ 0, & elsewhere \end{cases}$$

$$h(n) = \begin{cases} 2, & -1 \leq n \leq 2 \\ 0, & elsewhere \end{cases}$$

(b) How can the linear convolution of a finite length sequence with an infinite length sequence be performed? Illustrate.

8+7

MODULE 3 *(Answer any two questions)*

5.

(a) Synthesize the expression of Discrete Time Fourier Transform for any arbitrary finite length sequence using the concept of vector-space representation.

(b) Determine the output sequence of the system with impulse response $h(n) = \left(\frac{1}{2}\right)^n u(n)$ when the input is the complex exponential sequence $x(n) = Ae^{j\pi n}/2, -\infty < n < \infty$

10+5

6.

(a) By means of the DFT and IDFT, determine the response of an LTI system with impulse response $h(n) = \{1,\ 2,\ 3\}$ to the input sequence $x(n) = \{1,\ 2,\ 2,\ 1\}$.
↑ ↑

(b) Calculate the speedup of 8-point FFT over the brute force method.

12+3

7.

(a) Let $G(z)$ be the z-transform of any signal $g(n)$ with ROC $\mathcal{R}_g$. Find out the z-transform of the shifted signal $g(n - n_0)$ along with its ROC.

(b) Determine all possible signals $x(n)$ associated with the z-transform $X(z) = \frac{5z^{-1}}{(1-2z^{-1})(3-z^{-1})}$

(c) Find out the z-transform of the two-sided sequence $v(n) = \alpha^{|n|}$. What is its ROC?

3+8+4

MODULE 4 *(Answer any two questions)*

8.

(a) A length-9 Type 1 real-coefficient FIR filter has the following zeros: $z_1 = -0.5$, $z_2 = 0.3 + j.0.5$, $z_3 = -\frac{1}{2} + j.\frac{\sqrt{3}}{2}$. Determine the locations of remaining zeros. What is the transfer function of the filter? Is it a minimum-phase filter?

(b) What do you understand by moving average filter (MAF)? Find out the system function of a second order MAF and show the locations of poles and zeros in the z-plane. What inference can you draw about its frequency response?

9+6

9.

Design a digital Butterworth filter using impulse invariant transformation for the following specification:

$$0.8 \le |H(e^{j\omega})| \le 1, \quad 0 \le \omega \le 0.2\pi$$
$$|H(e^{j\omega})| \le 0.2, \quad 0.6\pi \le \omega \le \pi$$

Assume T=1 sec.

15

10.

(a) Realize the transpose of the FIR structure shown in Fig. 1 below. Write down the expression of system function derived from the structure.

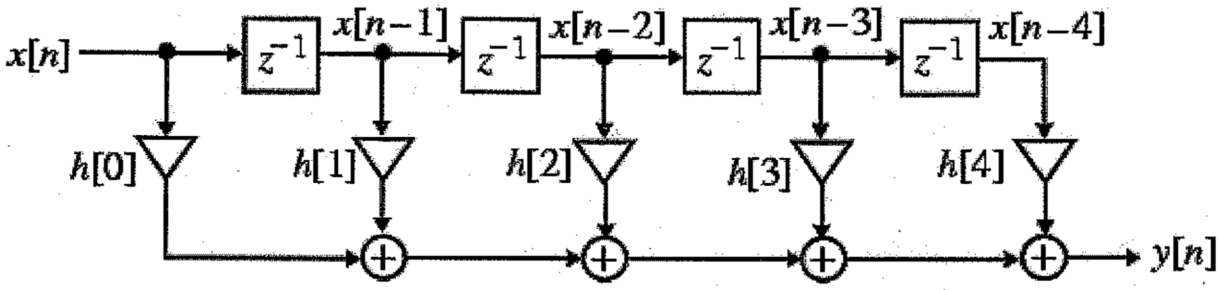

Fig. 1

(b) Find out the system function of the filter shown in Fig. 2 below. Hence, develop the difference equation which relates the input to output. Is the structure canonic?

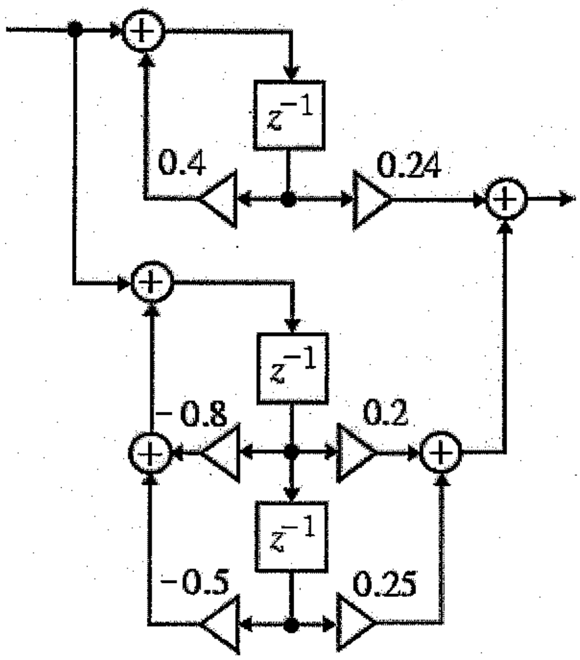

Fig. 2

7+8

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