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Question Paper Code : 20521

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2022.

Fifth/Eighth Semester

Electrical and Electronics Engineering

EE 8591 — DIGITAL SIGNAL PROCESSING

(Common to : Electronics and Instrumentation Engineering/Instrumentation and Control Engineering)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Determine the Nyquist rate of an analog electrocardiogram (ECG) signal containing useful frequencies up to 100 Hz. Suppose this signal is sampled at 250 samples / sec, identify the highest frequency that can be represented uniquely at this sampling rate.

2. Determine the power and energy of the following signal:

$$x(n) = \begin{cases} 0.9, & n \geq 0 \\ 0.2, & n < 0 \end{cases}$$

3. State any two properties of Z-transform and prove it.

4. Determine the inverse-z-transform of the following signal:

$$X(z) = \frac{1}{1 - 1.5z^{-1} + 0.5z^{-2}}$$

When ROC is $|z| > 1$.

5. Prove that multiplication of DFT's X(K) and Y(k) is the circular convolution of x(n) and y(n).

6. Draw the basic butterfly of a radix-2 DIF FFT algorithm.

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7. Draw the Direct form II transpose structure for an IIR filter have N coefficients.

8. Establish the relationship between analog and digital frequencies in converting an analog IIR filter to a digital filter using impulse invariance technique.

9. Discuss the differences between Digital signal processors and other microprocessors.

10. What is circular buffering in the context of Digital signal processors?

PART B — (5 × 13 = 65 marks)

11. (a) (i) Examine the following systems with respect to the properties of linearity, time invariance, causality and stability (8)

(1) $y(n) = x(n)\cos wn$

(2) $y(n) = Round[x(n)]$.

(ii) A discrete time signal $x(n) = \cos\left(\frac{\pi}{10}\right)n$ is quantized with a resolution of a $\Delta = 0.1$ or $\Delta = 0.02$. How many bits are required in the A/D converter in each case? (5)

Or

(b) (i) Two discrete time systems T1 and T2 are connected in cascade to form a new system T.

Prove or disprove the following statements with examples: (8)

(1) If T1 and T2 are causal then T is causal

(2) If T1 and T2 are non-linear then T is non-linear

(3) If T1 and T2 are linear and time invariant, interchanging T1 and T2 does not change the system T

(4) If T1 and T2 are stable, then T is stable.

(ii) In a discrete time system, show that even and odd parts of a real sequence are respectively even and odd sequences. (5)

12. (a) (i) Determine the convolution of the following graphically: (10)

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

$$h(n) = \delta(n) - \delta(n-1) + \delta(n-4) + \delta(n-5)$$

(ii) Compute the correlation of the output $y(n)$ to the input given in Q12(a) (i). (3)

Or

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(b) (i) Determine the Z-transform of the signal (7)

$$x(n)=\left(\frac{1}{2}\right)^n[u(n)-u(n-10)]$$

(ii) Using the properties of Z-transform, determine the Z-transform of the following given $x(n)$ in question 12. (a)(i). (6)

(1) $nx(n)$

(2) $x(n+1)+x(n-3)$

13. (a) (i) Compute the eight-point FFT using DIF algorithm for the sequence given by $x(n)=\{1, 2, 4, 6, 8, 2, 6, -1\}$ (9)

(ii) Find the output $y(n)$ of a filter whose impulse response is $h(n)=\{1, 1, 1\}$ and input signal $x(n)=(3, -1, 0, 1, 3, 2, 0, 1, 2, 1\}$ using overlap-save method. (4)

Or

(b) (i) Find the output $y(n)$ of a filter whose impulse response is $h(n)=\{1,1,2,1\}$ and input signal $x(n)=(1,-1,1,2,1,0,1,-4,3,2,1,0,1,1,1)$ using overlap-add method. (4)

(ii) Compute the signal $x(n)$ using DIT algorithm for the following (9)

$X(k)=\{12, 1-j2.414, 0, 1-j0.4142, 0, 1+j0.4142, 0, 1+j2.414\}$

14. (a) (i) Design a FIR band pass filter for the following specification and realize it using Direct Form structure with linear phase characteristics. (8)

$$H_d(w)=\begin{cases}e^{-j3w} & \frac{\pi}{3}\le|w|\le\frac{2\pi}{3}\\ 0 & otherwise\end{cases}$$

Use Hamming window for terminating the desired frequency response.

(ii) Design a FIR band pass filter using frequency sampling technique for the following specification (5)

Pass band edges = 1000 Hz and 3000 Hz

Sampling frequency = 8,000 Hz

Filter Length = 9

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(b) (i) Design a digital low pass Butterworth filter using bilinear transformation technique for the following specification with T = 1 sec. (9)

Passband gain = 0.9

Passband edge = 0.2π

Stopband edge = $0.5\,\pi$

Stopband gain = 0.1

(ii) Determine the parallel structure realization in Direct Form I for the system function $H(z)$ determined in Question 14. b. (i) (4)

15. (a) Draw the architecture of a typical Digital signal processor and explain the blocks in detail. (13)

Or

(b) Explain the addressing formats and functional modes of any DSP and discuss how it is different from traditional architectures. (13)

PART C — (1 × 15 = 15 marks)

16. (a) (i) Show that a relaxed LTI system is causal if and only if (5)

$$h(n) = 0, \text{ for } n < 0$$

(ii) We want to design a causal discrete-time LTI system with the property that if the input is,

$$x(n) = \left(\frac{1}{2}\right)^n u(n) - \frac{1}{4}\left(\frac{1}{2}\right)^{n-1} u(n-1)$$

then the output is $y(n) = \left(\frac{1}{3}\right)^n u(n)$

(1) Determine the impulse response $h(n)$ and the system function $H(z)$ of the system (4)

(2) Find the difference equation of the system. (3)

(3) Realize it using Direct form II. (3)

Or

(b) (i) Explain the following in DSP processors :

(1) addressing formats (4)

(2) functional modes. (4)

(ii) List 4 commercial DSP processors and mention its applications briefly. (7)

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