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HERITAGE INSTITUTE OF TECHNOLOGY

M. Tech. 1st. Semester Examination. 2014 Session : 2014-15

Discipline : AEIE

Paper Code : AEIE5102 Paper Name : Digital Signals and Systems

Time Allotted : 3 hrs Full Marks : 70

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: 10 x 1=10

(i) The sampling frequency of the following analog signal, $x(t) = 5\sin 150\pi t + 2\cos 50\pi t$ should be,

(a) greater than 75 Hz (b) greater than 150 Hz
(c) less than 150 Hz (d) greater than 50 Hz

(ii) The unit step signal $u(n)$ delayed by 3 units of time is denoted as,

(a) $u(n+3) = 1; \quad n \geq 3$ $= 0; \quad n < 3$
(b) $u(3-n) = 1; \quad n \geq 3$ $= 0; \quad n < 3$
(c) $u(n-3) = 1; \quad n \geq 3$ $= 0; \quad n < 3$
(d) $u(n+3) = 1; \quad n \geq -3$ $= 0; \quad n < -3$

(iii) An LTI system is stable, if the impulse response is

(a) $\sum_{n=-\infty}^{\infty} |h(n)| = 0$ (b) $\sum_{n=-\infty}^{\infty} |h(n)| < \infty$
(c) $\sum_{n=-\infty}^{\infty} |h(n)| \neq 0$ (d) either (a) or (b)

(iv) Which of the following signal is the example of deterministic signal?

(a) step (b) ramp
(c) exponential (d) all of the above

(v) If $DFT\{x(n)\} = X(k)$, then $DFT\{x(n+m)_N\}$

(a) $X(k)e^{\frac{-j2\pi km}{N}}$ (b) $X(k)e^{\frac{-j2\pi k}{mN}}$
(c) $X(k)e^{\frac{j2\pi km}{N}}$ (d) $X(k)e^{\frac{-j2\pi k}{mN}}$

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(vi) If $X(k)$ consists of $N-$number of frequency samples, then its discrete frequency locations are given by,

(a) $f_k = \frac{kF_s}{N}$ (b) $f_k = \frac{F_s}{N}$

(c) $f_k = \frac{kN}{F_s}$ (d) $f_k = N$

(vii) The number of multipliers and adders required for direct form realization of N^{th} order FIR system are,

(a) $N, N+1$ (b) $N, N-1$

(c) $N+1, N$ (d) $N-1, N+1$

(viii) The quantization error increases, when the order of the system 'N' increases in case of

(a) direct form realization (b) cascade or parallel form realization

(c) all IIR systems (d) all FIR systems.

(ix) For short-time, low-energy transients, the change in the spectrum is easily detected by

(a) Fourier Transform (b) Wavelet Transform

(c) Both (a) and (b) (d) None of (a) and (b)

(x) If the scale of a wavelet function is decreased by r, its width

(a) gets multiplied by $2^{r/2}$ (b) gets multiplied by 2^r

(c) gets divided by $2^{r/2}$ (d)remains unchanged

Group - B

2.(a) Let an analog signal, $x_a(t) = 10\cos 100\pi t$. If the sampling frequency is 75 Hz, find the discrete time signal $x(n)$. Also find an alias frequency corresponding to $F_s = 75$ Hz.

(b) What are energy and power signals? Test whether the signal $x(n) = \left(\frac{1}{4}\right)^n u(n)$ is energy or power signal?

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3.(a) Determine whether the signal $x(n)=\cos\left(\frac{\pi}{3}n\right)$ is energy signal or power signal.

(b) Define circular convolution. Find the circular convolution of the two sequences, $x_1(n)=\{\underset{\uparrow}{2},1,2,1\}$ and $x_2(n)=\{\underset{\uparrow}{1},2,3,4\}$.

Group – C

4.(a) Find the DFT of the sequence $x(n)=\{1,1,0,0\}$. Also plot its magnitude and phase spectrum.

(b) Proof that, if $DFT\{x(n)\}=X(k)$, then $DFT\{x_1(n)x_2(n)\}=\frac{1}{N}[X_1(k)\otimes X_2(k)]$. 6+6= 12

5.(a) What is the drawback of Fourier transform that is overcome by wavelet transform? Define continuous wavelet transform. Why is the discrete wavelet transform needed?

(b) Show the block diagrams of analysis and synthesis filters to perform two-band subband coding and decoding. (2+2+2)+6 = 12

Group – D

6.(a) For the analog transfer function $H(s)=\frac{1}{(s+1)(s+2)}$, determine $H(z)$ using impulse invariant technique. Assume $T=1$ sec.

(b) What is the disadvantage of designing FIR filter using Fourier series method? Design an FIR filter using rectangular window to approximate an ideal low pass filter with pass band gain of unity, cut-off frequency of 850 Hz and working at a sampling frequency of $f_s=5000$ Hz. The length of the impulse response should be 5. 5+(2+5) = 12

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7.(a) What is the advantage in linear phase realization of FIR systems?

(b) A discrete time signal x(n) is

$x(n) = \cos(2\pi f_1 n) + \cos(2\pi f_2 n)$; n = 0, 1, 2, 3.....7.

Determine the power spectrum for sequence L = 8, 16 at various values of $f_{1,2}$ if $f_2 = f_1 + \Delta f$. 2+10 = 12

Group – E

8.(a) What is multirate digital signal processing?

(b) Implement a two-stage decimator for the following specification:
Sampling rate of the input signal $x(n)$ is $F_S = 20,000Hz$, Decimation factor, D = 100, Pass band = 0 to 50 Hz, Transition ripple = 0.01, Stop band ripple = 0.002. 3+9 = 12

9. Given a wide-sense stationary random process $x(n)$, we would like to design a "linear predictor" that will predict the value of $x(n+1)$ using a linear combination of $x(n)$ and $x(n-1)$, such that $x(n+1) = ax(n) + bx(n-1)$, where a and b are constants. Assume that the process has zero mean $E\{x(n)\} = 0$ and that we want to minimize the mean-square error $\xi = E\{[x(n+1)\} - \hat{x}(n+1)]^2\}$.
(a) With $r_x(k)$ the autocorrelation of $x(n)$, determine the optimum predictor of $x(n)$ by finding the values of a and b that minimizes the mean square error.
(b) What is the minimum mean-square error of the predictor? Express your answer in terms of the autocorrelation $r_x(k)$?
(c) If $x(n+1)$ is uncorrelated with $x(n)$, what form does the predictor take?
(d) If $x(n+1)$ is uncorrelated with both $x(n)$ and $x(n-1)$, what form does the predictor take? 4+4+2+2= 12