Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME – SEMESTER II (NEW) – • EXAMINATION – SUMMER 2016

Subject Code: 2724111 **Date: 25/05/2016**

Subject Name: Statistical Signal Processing

Time:10:30 am to 01:00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** What do you mean by Wide Sense Stationary (WSS) Process? List out the important four properties of WSS Process. **07**

(b) Consider the complex harmonic process $x(n) = Ae^{j(n\omega_0+\emptyset)}$, where $\emptyset$ is a random variable that is uniformly distributed between $-\pi$ and π. Compute the mean and Autocorrelation of the process. **07**

Q.2 **(a)** Explain Spectral Factorization in detail with suitable mathematics. **07**

(b) Determine whether or not the following are valid autocorrelation matrices. If they are not, explain why not. **07**

(1) R1 = $\begin{bmatrix} 4 & 1 & 1 \\ -1 & 4 & 1 \\ -1 & -1 & 4 \end{bmatrix}$, (2) R2 = $\begin{bmatrix} 2 & j & 1 \\ -j & 4j & -j \\ 1 & j & 2 \end{bmatrix}$

OR

(b) Compute the power spectrum of the given WSS random process **07**

(1) $r_x(k) = \delta(k) + 2(0.5)^{|k|}$

(2) $r_x(k) = \begin{cases} 10 - |k|; & |k| < 10 \\ 0; & otherwise \end{cases}$

Q.3 **(a)** Explain ARMA(p,q) process in detail with suitable mathematics. **07**

(b) Consider $x(n) = \begin{cases} (-1)^n, & n \geq 0 \\ 0, & n < 0 \end{cases}$. Compute the AR model parameters using Autocorrelation and Covariance method. **07**

OR

Q.3 **(a)** Explain: Cramer Rao Theorem in detail with suitable mathematics. **07**

(b) Let $X_1, X_2, \ldots\ldots, X_N$ are Gaussian Random sequence with known variance σ^2 and unknown mean μ. Find CR Bound and hence show that $\hat{\mu}$ is an efficient estimator. **07**

Q.4 **(a)** Derive the equation for Causal IIR Wiener filter design. **07**

(b) Suppose that we wish to estimate a signal *d(n)* from the noisy observation $x(n) = d(n) + v(n)$, where $v(n)$ is unit variance white noise that is uncorrelated with $d(n)$. The signal $d(n)$ is an AR(1) process that is generated by the difference equation $d(n) = 0.8d(n-1) + w(n)$, where $w(n)$ is white noise with variance $\sigma^2_w = 0.36$. Therefore $r_d(k) = (0.8)^{|k|}$. Compute the Optimum Causal wiener filter respone, *H(z)*. **07**

OR

Q.4 **(a)** Derive the Wiener-Hopf equations and minimum mean square error for the for FIR Wiener filter. **07**

(b) Explain LMS Algorithm in detail with suitable mathematics. **07**

Q.5 **(a)** A Bandlimited continuous time signal has bandlimited power spectrum that is zero for $E|\Omega| >= 2\pi(10^4)$ rad/s. If the signal is sampled at Nyquist rate over time interval of 10sec and power spectrum is estimated by Bartlett method then **07**

(1) Length of data of 10sec.

(2) If radix-2 FFT used to computer periodogram, what is the minimum length of FFT if we want to obtain power spectrum at equally spaced frequency no more than 10Hz apart.

(3) If segment length L is kept same as the FFT length obtained in previous step, how many segments k are avail?

(b) Explain Welch Method for power spectrum estimation using suitable mathematics. **07**

OR

Q.5 **(a)** Explain Bartlett method for power spectrum estimation using suitable mathematics. **07**

(b) Derive the equation for power spectrum estimation using maximum entropy method. **07**

****