Reg. No. :

Question Paper Code : 10184

M.E./M.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

First Semester

Applied Electronics

AP 5152 — ADVANCED DIGITAL SIGNAL PROCESSING

(Common to M.E. Communication Systems/M.E. Communication and Networking/ M.E. Digital Signal Processing/M.E. Electronics and Communication Engineering)

(Regulation 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is necessary and sufficient condition for a random process to be ergodic in mean?

2. The input to a linear shift invariant system with impulse response

$$h(n) = \delta n - 0.5\delta(n-1)$$

is zero-mean white Gaussian process with variance 1. What is the power spectrum at the output of the system?

3. What is meant by bias and consistency of an estimator?

4. How do you improve the quality of the periodogram as a power spectrum estimator?

5. What is meant by ARMA process?

6. For what reason do we use linear estimator that minimize the mean squared error criterion?

7. What is meant forward and backward linear prediction?

8. What is meant by whitening filter?

9. What is an adaptive filter and mention its applications?

10. Consider the use of a white-noise sequence of zero mean and unit variance as the input to the steepest-descent algorithm. What is the condition for convergence of the algorithm in mean square?

PART B — (5 × 13 = 65 marks)

11. (a) The input to an LSI system with impulse response $h(n) = \delta(n) + 0.5\delta(n-1) + 0.25\delta(n-2)$ is a zero-mean wide-sense stationary random process with autocorrelation sequence

$$r_x(k) = \left(\frac{1}{4}\right)^{|k|}$$

Find the variance and autocorrelation of the output of the system. (13)

Or

(b) The power spectrum $S_X(\omega)$ of a WSS random process $x(n)$ is given by

$$S_X(\omega) = \frac{25 - 24\cos\omega}{26 - 10\cos\omega}$$

Find the system function $H(z)$ of a filter that produces white-noise with unit variance at its output when the input is $x(n)$. (13)

12. (a) Consider the peiodogram estimator $\hat{S}_X(\omega)$ the observation $x(n)$, $0 \le n \le N-1$ at zero frequency (that is, $\hat{S}_X(\omega)$ at $\omega = 0$ denoted as $\hat{S}_X(0)$.

(i) If $x(n)$ is real valued zero-mean white Gaussian process with variance σ_X^2, determine the mean and variance of $\hat{S}_X(0)$. (7)

(ii) Determine whether $\hat{S}_X(0)$ is a consistent estimator. (6)

Or

(b) With necessary expression, briefly explain the Bartlett's spectrum estimation method. (13)

13. (a) Derive Yule-Walker equations for AR process and explain power spectrum estimating using AR model parameters. (13)

Or

(b) Derive the Wiener-Hopf equations and MMSE for optimum FIR filter. (13)

14. (a) The first four samples of the autocorrelation sequence of a signal $x(n)$ are $r_x(0)=1$, $r_x(1)=0.8$, $r_x(2)=0.6$ and $r_x(3)=0.4$. Compute the forward linear predictor, the backward linear predictor and the corresponding MMSE. (13)

Or

(b) Using Levinson recursion, solve the following Toeplitz systems of equations (13)

$$\begin{bmatrix} 4 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 4 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 9 \\ 6 \\ 12 \end{bmatrix}$$

15. (a) Derive the Steepest Descent Algorithm (SDA) for updating the weight vector of an adaptive filter of length N. Derive the natural mode of the SDA and formulate the transient behavior of weight vector. (13)

Or

(b) Derive the equation for exponentially weighted recursive least squared adaptive algorithm and explain. (13)

PART C — (1 × 15 = 15 marks)

16. (a) Consider an optimum Wiener filter of length-2 specified by the input auto-correlation matrix R and the cross-correlation vector, between the input and the desired response, is $[1 \quad 0.5]^T$. The eigenvalues λ_1, λ_2 and its corresponding eigen vectors q_1, q_2 of R are given by

$$\lambda_1 = 0.75,\ \lambda_2 = 1.25,\ q_1 = (1/\sqrt{2})\,[-1 \quad 1]^T,\ q_2 = (1/\sqrt{2})\,[1 \quad 1]^T$$

(i) Determine the optimum impulse response of the Wiener filter (8)

(ii) Determine the minimum mean squared error of the estimate of the desired response. (7)

Or

(b) The LMS algorithm for updating the coefficient vector, $w(n)$, at time 'n' of the Nth order FIR adaptive filter is developed by minimizing the instantaneous squared error

$$\xi(n) = |e(n)|^2, \text{ where } e(n) = d(n) - w^T(n-1)\, x(n)$$

Suppose that the instantaneous squared error used in the LMS algorithms is modifies as follows :

$$\xi'(n) = |e(n)|^2 + \beta w^T(n-1) w(n-1), \text{ where } \beta > 0.$$

(i) Derive the coefficient update recursion for $w(n)$ at time 'n' by minimizing $\xi'(n)$. (8)

(ii) Derive the condition on the step size μ that will ensure that $w(n)$ converges in the mean. (7)

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