Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M.E –IIst SEMESTER–EXAMINATION – JULY- 2012

Subject code: 1722601 Date: 06/07/2012

Subject Name: Advanced Digital Signal Processing and Applications

Time: 10:30 am – 13:00 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)** Demonstrate that wide sense stationary random process can be represented as the output of a causal and causally invertible linear system excited by a white noise process. **07**

(b) What do you understand by Backward Linear prediction. For a Backward Linear predictor find the expression for the system function $B_p(z)$.Show that $B_p(z)$ is the reverse polynomial of $A_p(z)$,the system function of Forward linear prediction. **07**

Q.2 **(a)** Explain and compare AR and ARMA random processes with mathematical expressions for system functions as well as lattice structures. **07**

(b) Given a quadratic MSE function for the Wiener filter: **07**

$$J = 40 - 20w + 10w^{2}.$$

Find the optimal solution for w^{*} to determine Jmin by
(i) achieving the minimum MSE Jmin and .
(ii) using the steepest descent method with an initial guess as $w_0 = 0$ and $\mu = 0.04$ by iterating three times.

OR

(b) Design a Wiener FIR filter of length of M=2 with input to the filter with sequence x(n)=s(n)+w(n) for an AR(1) process satisfying the equation s(n)=0.4s(n-1)+v(n) where{v(n)} is white noise sequence with variance **07**
$\sigma_v^2 = 0.49$ and {w(n)} is the white noise sequence with
$\sigma_w^2 = 1$.Determine (i) $\Gamma_{ss}(f)$ (ii)For filter coefficients h(0) and h(1) for $\gamma_{ss}(m) = (0.4)^m$.

Q.3 **(a)** Obtain estimate of the statistical mean and autocorrelation of the random process from a single realization x(n). **07**

(b) An ARMA Process has an autocorrelation $\{\gamma_{xx}(m)\}$ whose Z transform is given as **07**

$$\Gamma_{xx}(z) = \frac{9\left(z-\frac{1}{3}\right)(z-3)}{\left(z-\frac{1}{2}\right)(z-2)} \qquad \frac{1}{2} < |z| < 2$$

Determine (i) the filter H(z) for generating {x(n)} from a white noise input sequence (ii) a stable whitening filter for the sequence {x(n)}.

OR

Q.3 **(a)** Show that for the optimum IIR Wiener filter , **07**

(i)MMSE$_\infty$= $\sigma_d^2 - \sum_{k=0}^{\infty} h_{opt}(k)\gamma_{dx}^*(k)$ (ii) Q(z)= $\frac{1}{\sigma_i^2}[\Gamma_{di}(z)]_+$

(b) Determine the system function H(z) for the FIR filter described by the lattice coefficients by the lattice coefficients K_1=0.6, K_2=0.3, K_3=0.5, K_4=0.9.Find h(n). **07**

Q.4 **(a)** Explain the application of adaptive filter for Echo cancellation in data transmission over telephone lines using Symbol rate echo canceller. **07**

(b) Define : (i) Stationary Random processes (ii)Ensemble Averages (iii) Prediction error (iv) Cross Power density spectrum (v) innovation process (vi) Adaptive filter (vii) Toeplitz matrix **07**

OR

Q.4 **(a)** What is Least mean-squared error criterion? Explain in detail LMS algorithm for FIR filters adaptive filter based on steepest descent method. **07**

(b) Determine the reflection coefficients $|k_m|$ of the Lattice filter corresponding to an FIR filter described by the system function **07**

$$H(z) = A_3(z) = 1 + \frac{13}{24}z^{-1} + \frac{5}{8}z^{-2} + \frac{1}{3}z^{-3}$$

Q.5 **(a)** Obtain the relation between filter parameters and autocorrelation sequence and obtain Yule-Walker equation for AR process from the generalized relations for ARMA process . **07**

(b) Explain the cases of linear estimation problems such as signal prediction and smoothing of Wiener filter subject to an input sequence x(n)=s(n)+w(n) where s(n) and w(n) are uncorrelated random sequences,and output sequence is y(n) with normal linear Wiener-Hopf equations for the minimization of the minimum mean square error for both . **07**

OR

Q.5 **(a)** Explain Polyphase decomposition process.Illustrate for FIR structure**.** **07**

(b) For a single-stage decimator with the following specifications: **07**
Sampling rate =8 kHz, Decimation factor M = 4
Input audio frequency range = 0–800 Hz,
Passband ripple = 0.02 dB, Stopband attenuation =46 dB
a. draw the block diagram for the decimator;
b. determine the window type, filter length, and cutoff frequency if the window method is used for the anti aliasing FIR filter design .

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