M.E. (ETC) 1st Semester Final Examination, 2013-2014
Digital Signal Processing & Its Applications(ETC- 940)

Full Marks: 70 **Time: 3 hours**

Use separate answer scripts for each half

FIRST HALF

Answer Q. no.1 and any two from the rest

1. Discuss the problem of filtering a relatively long discrete-time signal using a FIR filter of short length (of impulse response). With an example discuss how overlap and add method can be used to solve the problem.

5+10

2. Discuss the method of designing the predictor for linear predictive coding. Mention its application.

8+2

3. a) Find the inverse Z-transform of the following function.

$$X(z) = \log(1-2z), \qquad |z| < 1/2$$

b) Determine the unit step response of the system given by following input-output equation

$$y(n) = a\,y(n-1) + x(n)\,, -1 < a < 1$$

when the initial condition is $y(-1) = 1$. $x(n)$ and $y(n)$ represent the input and output of the system respectively.

5+5

4. Derive an expression of discrete cosine transform (DCT-II) from the definition of discrete Fourier transform (DFT). Justify its use in image compression application.

8+2

SECOND HALF

Answer Q. No. 5 and any two from the rest

5. Consider the design of a causal IIR Wiener filter for p-step prediction,

$$\hat{x}(n+p) = \sum_{k=0}^{\infty} h(k)x(n-k)$$

(a) If $x(n)$ is a real-valued random process with power spectral density $P_x(z) = \sigma_x^2 Q(z)Q(z^{-1})$; find the system function of the causal Wiener filter that minimizes the mean-square error.

(b) If $x(n)$ is an AR(1) process with power spectrum $P_x(z) = \frac{1-a^2}{(1-az^{-1})(1-az)}$; find the causal p-step linear predictor and evaluate the mean-square error.

Or

A wide-sense stationary random process $d(n)$ is to be estimated from noisy observations, $x(n) = d(n) + v(n)$; where $v(n)$ is white noise with variance $\sigma_v^2 = 1$ with the first four values of the autocorrelation sequence is given by $\boldsymbol{r}_d = [1.5,\ 0,\ 1.0,\ 0]^T$. Assume that $d(n)$ and $v(n)$ are uncorrelated. Hardware constraints, however, limit the filter to have only three nonzero coefficients.

(a) Derive the optimum three-multiplier causal filter for estimating $d(n)$ and evaluate the mean-square error.

(b) Repeat part (a) for the noncausal FIR filter.

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6. Show that for an adaptive FIR filter, mean-square error at time 'n' is related to the minimum mean-square error ξ_{min} by

$$\xi(n) = \xi_{min} + \boldsymbol{u}_n^H \boldsymbol{\Delta}_x \boldsymbol{u}_n$$

,where the symbols enjoy their usual significances.

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7. A certain digital filter is having three zeros at $z = -1$, one pole at $z = 0.5$ and two poles at $z = 0.5\angle \pm 60°$. The filter has unity gain at dc. Determine the system function in the form:

$$H(z) = A[\frac{(1 + a_1 z^{-1})(1 + b_1 z^{-1} + b_2 z^{-2})}{(1 + c_1 z^{-1})(1 + d_1 z^{-1} + d_2 z^{-2})}]$$

, giving numerical values for the parameters $A, a_1, b_1, b_2, c_1, d_1$ *and* d_2.

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8. Convert the analog filter with the system function $H(s) = \frac{1}{(s+0.1)^2+16}$ into a digital IIR filter by means of Bilinear Transformation. The digital filter is to have a resonant frequency at 0.5π.

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