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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH DEGREE EXAMINATION, APRIL/MAY 2018

Branch: Electronics and Communication Engineering

Stream: Signal Processing

Course Code & Name: 01EC6306 Multirate Systems and Wavelets

Answer *any two full* questions from *each* part

Limit answers to the required points.

Max. Marks: 60 Duration: 3 hours

PART A

1. Consider the multirate structure of Fig. 1, where $H_0(z), H_1(z)$ and $H_2(z)$ are respectively, ideal zero phase real coefficient low pass, band pass and high pass filters with frequency response as indicated in Fig. 2. If the input is a real sequence with a Discrete-Time Fourier Transform as shown in Fig. 3, sketch the output waveforms $y_0(n)$, $y_1(n)$ and $y_2(n)$. 9

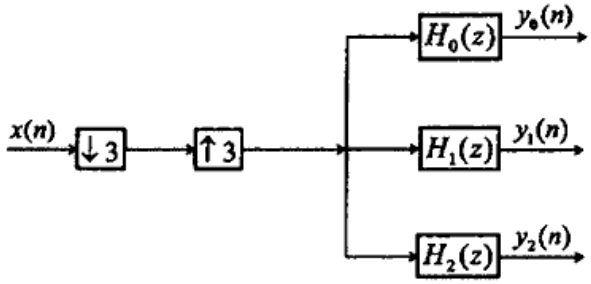

Fig. 1

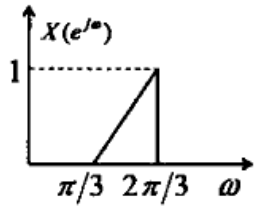

Fig. 3

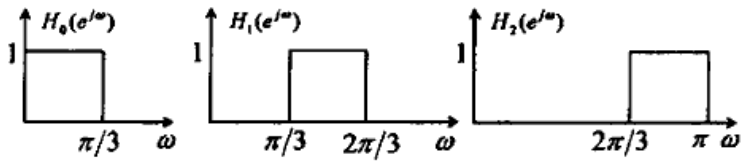

Fig.2

2. a. Determine the computational complexity of a single-stage decimator designed to reduce the sampling rate from 40KHz to 2KHz. The decimation filter is to be designed as an equiripple FIR filter with a pass-band edge at 800Hz, stop-band edge at 1000Hz, a pass-band ripple of 0.02, and a stop-band ripple of 0.01. Use Kaiser's formula to estimate the order of the FIR filter. 3

b. The above decimator is to be designed as a two stage structure ($M = M_1M_2, where\ M_1 = 10\ and\ M_2 = 2$). Compare the computational complexity of single-stage decimator design with that of the two-stage decimator design. Use the total multiplications per second as a measure of the computational complexity. 6

3. a. State and prove the noble identities of multi-rate systems. 4

b. In a 2 channel alias free Quadrature Mirror Filter bank, one of the filter is given by $H_0(z) = 12 + 4z^{-1} + 10z^{-2} + 2z^{-3} + 2z^{-4}$. Determine the remaining filters and find the transfer function. Draw the polyphase representation of the filter bank. 5

PART B

4. a. What are the limitations of Fourier Transform? How it is overcome in Short Time Fourier Transform? 3

b. Consider a function $f(t) \in V_1$, where $V_1 = Span_k\ \overline{\{\emptyset(2t-k)\}}$; Let the coefficients of the basis functions of V_1 for $f(t) = \{3, 5, 2, 6, 0, -2, 2, 4\}$, where $\emptyset(t)$ corresponds to Haar scaling function. (i) Can you express $f(t)$ in terms of basis functions of V_0, where $V_0 = Span_k\ \overline{\{\emptyset(t-k)\}}$. Justify your answer. (ii) Express $f(t)$ in terms of basis functions of V_0 and W_0 where $W_0 = Span_k\ \overline{\{\varphi(t-k)\}}$. Write the relation between V_0 , W_0 and V_1. 6

5. Design Daubechies Orthogonal Wavelet system with two vanishing moments using time domain approach. 9

6. a. Obtain two level Discrete Wavelet Transform of the sequence $x(n) = \{3, 5, 2, 6, 0, -2, 2, 4\}$ using normalized Haar wavelet implemented with Mallat Algorithm. 5

b. Check whether the following function is an admissible wavelet. 4

$$\psi(t) = (1-t^2)e^{-t^2/2}$$

PART C

7. Derive the Mallat Filterbank structure (Analysis & Synthesis) for a Biorthogonal Wavelet System starting from the basic two scale equations. 12

8. a. Differentiate between an orthogonal wavelet system and biorthogonal wavelet system. 4

b. Draw the Haar wavelet packet basis for three levels of decomposition. 4

c. What are the advantages of Wavelet Packet Transform over Wavelet Transform? 4

9. Obtain two level Discrete Wavelet Transform of the following sequence with normalized Haar Wavelet using lifting scheme. 12

Data = [34, 36, 36, 40, 38, 34, 34, 44]