B.E. Sem VII (Rev) EXTC Dec. 07

Discrete Time Signal processing.

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Con. 5151-07. **(REVISED COURSE)** **CD-7188**

(3 Hours) **[Total Marks : 100**

N. B. (1) Question No.1 is compulsory

(2) Attempt any four questions out of remaining six questions.

(3) Assume suitable data if required

1. A causal first-order digital filter is described by the system function

$$H(z) = b_0 \frac{1+bz^{-1}}{1+az^{-1}}$$ (10)

(a) Sketch the direct form I and direct form II realizations of this filter and find the corresponding difference equations.

(b) For a = 0.5 and b = - 0.6, sketch the pole zero pattern. Is the system stable? Why ?

(c) For a = - 0.5 and b = 0.5, determine b_0, so that the maximum value of $|H(\omega)|$ is equal to 1.

(d) Sketch the magnitude response $|H(\omega)|$ and the phase response $\angle H(\omega)$ of the filter obtained in part (c)

(e) In a specific application it is known that a = 0.8. Does the resulting filter amplify high frequencies or low frequencies in the input? Choose the value of *b* so as to improve the characteristics of this filter (i.e. make it a better lowpass or a better highpass filter).

2 (a) Sequence $x_p(n)$ is periodic repetition of sequence $x(n)$. What is the relationship between C_k of Discrete Time Fourier Series of $x_p(n)$ and DFT $X(k)$ of $x(n)$. (8)

(b) Determine the coefficients of a linear-phase FIR filter $y(n) = b_0x(n) + b_1x(n-1) + b_2x(n-2)$ such that

(i) It rejects completely a frequency component at $\omega_0 = \frac{2\pi}{3}$ (12)

(ii) Its frequency response is normalized so that $H(0) = 1$

(iii) Compute and sketch the magnitude and phase response of the filter to check if it satisfies the requirements.

3. (a) The z-transform of the sequence x(n) = u(n) – u(n – 7) is sampled at five points on the unit circle as follows

$$x(k) = X(z)\Big|_{z=e^{j\frac{2\pi k}{5}}} \qquad k = 0, 1, 2, 3, 4$$ (10)

Determine the inverse DFT $x'(n)$ of $X(k)$. Compare it with $x(n)$ and explain the results.

(b) An FIR digital filter has the unit impulse response sequence, h(n) = {2, 2, 1}. Determine the output sequence in response to the input sequence x(n) = {3, 0, - 2, 0, 2, 1, 0, -2, -1, 0} using overlap add convolution method. (10)

4. (a) What is a linear phase filter ? What conditions are to be satisfied by the impulse response of an FIR system in order to have a linear phase ? Define phase delay and group delay (10)

(b) Determine $H(z)$ for a Butterworth filter satisfying the following constraints

$$\sqrt{0.5} \le \left|H\left(e^{j\omega}\right)\right| \le 1 \qquad 0 \le \omega \le \frac{\pi}{2}$$ (10)

$$\left|H\left(e^{j\omega}\right)\right| \le 0.2 \qquad \frac{3\pi}{4} \le \omega \le \pi$$

with $T = 1\ s$. Apply impulse invariant transformation.

5. (a) Design an FIR digital filter to approximate an ideal low-pass filter with passband gain of unity, cut-off frequency of 850 Hz and working at a sampling frequency of f_s = 5000 Hz. The length of the impulse response should be 5. Use a rectangular window. (10)

(b) Draw a lattice filter implementation for the all pole filter (10)

$$H(z) = \frac{1}{1 - 0.2z^{-1} + 0.4z^{-2} + 0.6z^{-3}}$$

and determine the number of multiplications, additions, and delays required to implement the filter. Compare this structure to a direct form realization of $H(z)$ in terms of multiplies, adds and delays.

6. (a) Compare DFT and DCT (5)
(b) With the help of block diagram , explain architecture of TMS 32 C 5X series of processors. (8)
(c) A two pole lowpass filter has the system function (7)

$$H(z) = \frac{b_0}{\left(1 - p z^{-1}\right)^2}$$

Determine the values b_0 and p such that the frequency response $H(\omega)$ satisfies the conditions

$$H(0) = 1 \quad \text{and} \quad \left|H\left(\frac{\pi}{4}\right)\right|^2 = \frac{1}{2}$$

7. Write short notes on the following : (20)
(a) Digital Resonator
(b) Applications of DCT
(c) Frequency domain characteristics of the different types of window functions
(d) Coefficient quantization in IIR filters