53 (EC 603) DISP

2018

DIGITAL SIGNAL PROCESSING

Paper : EC 603

Full Marks : 100

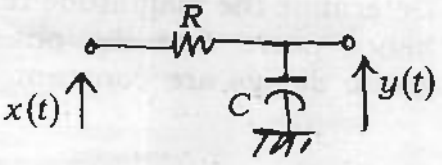
Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

1. *(a)* Establish the relation between analog and digital frequency. 5

(b) In the given low-pass RC circuit shown below with $R = 1M\Omega$ and $C = 1\mu F$, determine the equivalent discrete-time expression for the circuit response $y(n)$ when the input is given by $x(t) = exp(-2t)$, and the sampling frequency is 50*Hz*. 15



Contd.

2. *(a)* Find the impulse response $h(n)$ for each of the causal, discrete-time LTI systems satisfying the following difference equations and also indicate whether each system is FIR or IIR system : 5×3=15

(i) $y(n)=x(n)-2x(n-2)+x(n-3)$

(ii) $y(n)+2y(n-1)=x(n)+x(n-1)$

(iii) $y(n)-0{\cdot}5y(n-2)=2x(n)-x(n-2)$

(b) Find the z-transformation of *(i)* $x(n)=1$

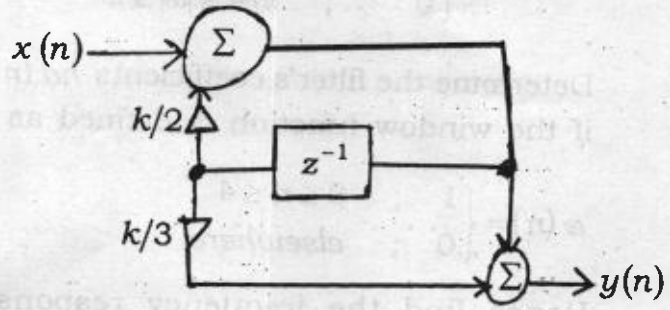
(ii) $x(n)=2^n\,u(n-2)$. 5

3. *(a)* An FIR filter $(N=II)$ is characterised by the following transfer function :

$$H(z)=\sum_{n=0}^{N-1} h(n)z^{-n}$$

Determine the magnitude response and hence prove that the phase and the group delays are constant. 10

(b) Consider the discrete-time system shown below. For what values of 'k' is the system BIBO stable? 10



4. (a) Design a single-pole low pass digital filter with a $3dB$ bandwidth of $0{\cdot}2\pi$ using bilinear transformation. The analog filter has a system response given by

$H(s) = \Omega c/(s + \Omega c)$; where 'Ωc' is the $3dB$ bandwidth of the analog filter. 10

(b) A digital low pass filter is to be designed with the following desired frequency response : 10

$$Hd(\omega) = \begin{cases} e^{-j\omega \times 2} ; & -\pi/4 \le \omega \le \pi/4 \\ 0 ; & \pi/4 \le |\omega| \le \pi \end{cases}$$

Determine the filter's coefficients $hd(n)$ if the window function is defined as

$$\omega(n) = \begin{cases} 1 ; & 0 \le n \le 4 \\ 0 ; & elsewhere \end{cases}$$

Hence find the frequency response $H(\omega)$ of the designed filter.

5. (a) Determine the lowest order of a transfer function $Ha(s)$ having maximally flat low pass characteristics with a $1dB$ cutoff frequency at $1kHz$ and a minimum attenuation of $40dB$ at $5kHz$. 8

(b) Design a digital LPF (Butterworth) using impulse invariant method to meet the following specifications : 12

(i) Pass band edge frequency = $1{\cdot}25kHz$

(ii) Stop band edge frequency = 2·75*kHz*.

(iii) Pass band ripple $\leq 0{\cdot}5dB$

(iv) Stopband attenuation $\geq 15dB$

Sampling frequency is 10*kHz*.

6. (a) Compute the DFT of the sequence

$$x(n) = \{4, 4+3i, 2, -4\}$$ 8

(b) Draw the complete signal flow graph of 8 point DIF-FFT algorithm. 12

7. (a) Draw the block diagram of linear convolution using DFT. 6

(b) What are the major factors that influence our choice of a specific realisation ? 6

(c) Write a short note on Frequency sampling realisation of FIR filter. 8

8. (a) Develop a Direct Form II structure with combined common delay for the following : 10

$$y(n) = 2x(n) - 3x(n-1) - x(n-2) + 1{\cdot}5x(n-3)$$

$$+ 5x(n-4) - 2{\cdot}5y(n-1) + 2y(n-2) - 1{\cdot}5y(n-3).$$

(b) A digital system is given with the difference equation .

$y(n) = 0{\cdot}9y(n-1) + x(n)$ with $x(n) = 0$ and initial condition $y(-1) = 4$. Explain zero input limit cycle effect. 10

9. (a) Find the circular convolution $y_c(n) = x(n) * h(n)$ where

$x(n) = \{1, -2, 4, 1{\cdot}5\}$ and $h(n) = \{3, 0, -2, 5\}$ 7

(b) Consider the transfer function of an analog filter $H(s) = (s+3)/s^2 + 4s + 13$. Now design the corresponding digital filter using impulse invariant method, consider sampling time = 0·1s. 10

(c) A system has impulse response given by $h(n) = -0{\cdot}25\delta(n+1) - 0{\cdot}5\delta(n) = 0{\cdot}25\delta(n-1)$ Is the system causal ? 3

10. (a) Find the inverse z-transform of

$$X(z) = \frac{z\left(z^2 - 4z + 5\right)}{(z-3)(z-1)(z-2)}$$

for ROC (i) $2 < |z| < 3$, (ii) $|z| < 1$ 10

(b) What are the advantages of digital filters over analog filters ? 5

(c) Why are FFT techniques so important in DSP ? 5

11. (a) What are the desirable and undesirable features of FIR filters ? 5

(b) Why FIR filters are known as all-zero filters ? 5

(c) Write short notes on *any two* from the following : 5+5

(i) Gibbs phenomenon

(ii) Overlap-add and Overlap-save methods

(iii) Design of FIR filter using window method.

12. Multiple choice type questions.
Choose the correct alternative : 10×2=20

(i) The output of a causal system :

(a) does not depend on the input

(b) depend on the present and future input

(c) does not depend on future input

(d) does not depend on the past and future input.

(ii) Advantage of DSP over analog signal processing is :

(a) greater accuracy

(b) flexibility in configuration

(c) digital realisation is cheaper

(d) all of these.

(iii) The system $y(n) = x(n) + 3x(n-1)$ is

(a) static

(b) linear

(c) dynamic

(d) non-linear

(iv) The system $y(n) = x(n) + nx(n-1)$ is

(a) non-causal and time invariant

(b) causal and time variant

(c) causal and time invariant

(d) non-causal and time variant.

(v) Which of the following is N-point DFT of $x(n)$:

(a) $X(k) = \sum_{k=0}^{N=1} x(n) \exp(-j2\pi kn \times N)$

(b) $X(k) = \sum_{k=0}^{N=1} x(n) \exp(-j2\pi kn / N)$

(c) $X(k) = \sum_{k=0}^{N=1} x(n) \exp(+j2\pi kn / N)$

(vi) The Fourier transform of a discrete and periodic sequence is —

(a) discrete and periodic

(b) continuous and periodic

(c) continuous and aperiodic

(d) discrete and aperiodic.

(vii) Which of the following error (s) arise (s) due to quantisation of numbers ?

(a) Input quantization error

(b) Product quantisation error

(c) Coefficient quantisation error

(d) All of these.

(viii) Which of the following is not a power signal ?

(a) unit step

(b) $exp\,(j\omega_0 n)$

(c) periodic sequence

(d) unit ramp sequence.

(ix) Consider an analog signal $x_a(t) = 3\cos 100\pi t$. The min. sampling rate required to avoid aliasing is

(a) $100Hz$

(b) $200Hz$

(c) 50 Hz

(d) 75 Hz.

(x) Zero padding indicates :

(a) Zeros appearing in $X(k)$ sequences

(b) Value of $X(k)$ are zero

(c) Dummy zero valued samples added

(d) None of these.
