B.E. INSTRUMENTATION AND ELECTRONICS ENGINEERING SECOND YEAR
SECOND SEMESTER – 2022
DIGITAL SIGNAL PROCESSING

Time: 3Hrs. Full Marks: 100

Module 1: Answer all the questions from Module-1

1. a) Comparison between energy and power signal.
   b) Obtain energy for the signal
   $x(n) = a^n u(n)$ *where* $|a| < 1$
   c) Determine whether the following systems are time-invariant or not.
   $$y(n) = x(n^2)$$
   d) Explain the given systems with respect to the following properties:
   i) Dynamic ii) time invariance iii) linearity iv) causality v) stability
   A) $y(n) = \sum_{k=-\infty}^{n} x(k)$ B) $y(n) = \text{sgn}[x(n)]$

e) Determine whether or not the following signals are periodic. If periodic specify its fundamental period
A) $x(n) = \cos(n/8)\cos(\pi n/8)$
B) $x(n) = \cos(n\pi/2) - \sin(n\pi/8) + 3\cos(\pi n/4 + \pi/3)$

f) Obtain the linear convolution of the following sequence

$x(n) = \{1,2,1,2\}$ *and* $h(n) = \{1,1,1\}$

(1+4+4+5+4+2)=20

Module 2: Answer any two questions from Module-2

2. a) Obtain **DTFT** of the below signals
A) $x(n) = a^n u(n) + a^n u(-n-1)$
B)
$x(n) = A$ *for* $0 \le n \le L-1$
0 *otherwise*
b) Calculate the DFT of the sequence $x(n) = \{1,1,0,0\}$

c) Given the two sequences of length 4 are:

$x(n)=\{0,1,2,3\}$

$h(n)=\{2,1,1,2\}$

Find the circular convolution in the graphical method

d) Compute the 8-point circular convolution for the following sequence

$x_1(n)=\{1,1,1,1,0,0,0,0\}$

$x_2(n)=\sin(\frac{3\pi n}{8}) \quad 0\le n\le 7$

{(2+3)+5+5+5}=20

3)

a) Why the result of circular and linear convolution is not the same?

b) Overlap Add method

c) Describe the Radix-2 Decimation in Time (DIT) algorithm. State the computational complexity using the FFT algorithm

(3+5+12)=20

4)

a) Determine the z-transform and sketch the ROC of :

$x(n)=(\frac{1}{3})^n \quad for \quad n>0$

$(\frac{1}{2})^{-n} \quad for \quad n<0$

b) Using differentiation property to obtain the Z-transformation of unit ramp sequence

c) Determine the Z-transform and ROC of

$x(n)=(\frac{1}{2})^{-n} \quad u(-n)$

d) Find the Z-transform of $x(n)=\frac{a^n}{n!} \quad , \quad n\ge 0$

e) Obtain the Z-transform of the signal

$x(n)=na^n u(n)$

(4+4+4+4+4)=20

5.

a) Find inverse Z-transform:

$X(Z)=\log(1+aZ^{-1}). \quad |Z|>|a|$

b) Find the linear convolution of x_1 (n) and x_2 (n) using Z-transform

$x_1(n) = \{1, 2, 3, 4\}$ and $x_2(n) = \{1, 2, 0, 2, 1\}$.
↑ ↑

c) Determine inverse z-transform of:

$$X(Z)=\frac{4Z^{-2}+3Z^{-1}+2}{\frac{1}{2}Z^{-2}-\frac{3}{2}Z^{-1}+1}$$ for causal sequence

d) Find the frequency response and impulse response of an LTI system whose input and output satisfy the difference equation

$$y(n)-\frac{1}{2}y(n-1)=x(n)+2x(n-1)+x(n-2)$$

(5+5+5+5)=20

Module-3: Answer any one question from Module-3

6. a) Develop direct form-II realization the transfer function

$$X(Z)=\frac{3+3.6Z^{-1}+0.6Z^{-2}}{1+0.1Z^{-1}-0.2Z^{-2}}$$

b) The transfer function of the discrete-time causal system is given by;

$$X(Z)=\frac{1-Z^{-1}}{1+0.2Z^{-1}-0.15Z^{-2}}$$ draw cascade and parallel realization of the system.

c) Develop the parallel form realization for the digital filter with transfer function

$$X(Z)=\frac{1+2Z^{-1}+Z^{-2}}{1-0.75Z^{-1}+0.125Z^{-2}}$$

d) Discuss bilinear transformation method to design digital filter

4+5+4+7=20

7. a

Find out $H(Z)$ using impulse invariance method at 5 Hz sampling frequency from $H(s)$ as given below :

$$H(s) = \frac{2}{(s+1)(s+2)}.$$

b) Write the comparison between Impulse invariance and the Bilinear transformation method

c)

The system transfer function of analog filter is given by,

$$H(s) = \frac{s+0.1}{(s+0.1)^2+16}$$

Obtain the system transfer function of digital filter using BLT which is resonant at $\omega_r = \frac{\pi}{2}$.

d)

Using bilinear transformation, design a butterworth filter which satisfies the following conditions :

$0.8 \leq |H(e^{j\omega})| \leq 1$ $\quad 0 \leq \omega \leq 0.2\pi$

$|H(e^{j\omega})| \leq 0.2$ $\quad 0.6\pi \leq \omega \leq \pi$

8. 6+2+6+6=20

a.

A digital low pass IIR filter is to be designed with butter- worth approximation using bilinear transformation technique. Find the order of filter to meet the following specifications.

(i) Passband magnitude is constant within 1 dB for frequencies below 0.2π.

(ii) Stopband attenuation is greater than 15 dB for frequencies between 0.3π to π.

b. Discuss the design of the FIR filter using the window method.

c.

Design a linear phase FIR low pass filter of order seven with cut-off frequency 1 rad/sec using rectangular window.

6+7+7=14

Module-4: Answer all the questions Module-4

9)

A. What does *multi-rate* mean?

b. Discuss the use of multi-rate DSP?

c) State the Various advantages of Multirate DSP

d) What are the categories of multi-rate?

e) Discuss the Basic Sampling Rate Alteration Devices

4+4+4+4+4=20