MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 512: DIGITAL SIGNAL PROCESSING

DATE: 28/7/2017 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

This paper consists of FIVE questions. Answer Question ONE and any other TWO questions

QUESTION ONE (COMPULSORY-30 MARKS)

(a) Figure 1 shows a discrete signal sequence.

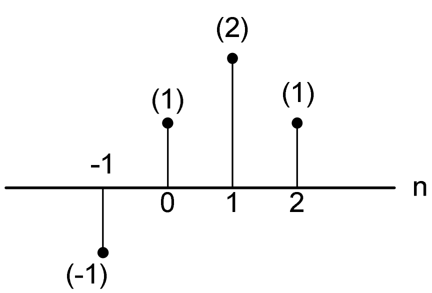


Figure 1

Plot the following sequences

i. $y_1[n] = x[2n-2]$

ii. $y_2[n] = x[-n-1]$

iii. $y_3[n] = x[n] \times \delta[n-1]$

iv. $y_4[n] = x[n-1] \times u[n-1]$

v. $y_5[n] = x[n] \times x[n-1]$

(10 marks)

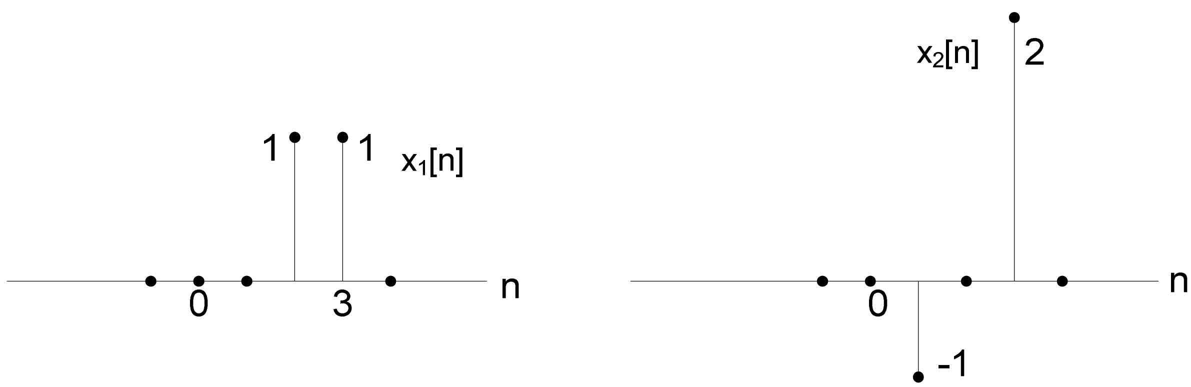
(b) Computationally efficient algorithms for computing the DFT exploit the following properties:

(Periodicity): $W_N^{k+N} = W_N^k$

(Symmetry): $W_N^{k+\frac{N}{2}} = -W_N^k$

where $W_N = e^{-2\pi/N}$.

i. Explain what W represent in this context and how it relates to the DFT
ii. Prove that the two properties above are true
iii. Suppose we take the 4-point FFT of the signals in Fig.3, multiply them in frequency and take the inverse result. Compare the result with that obtained by convolving the two sequences in the time domain



(10 marks)

(c) A discrete system is described by the difference equation $y[n] = 3x[n] + 5$. Determine whether the system is
i. linear
ii. time-invariant

(6 marks)

(d) (i) Distinguish between decimation in time and decimation if frequency FFT algorithms
(ii) Explain how pipelining improves the operation of a DSP processor.

(4 marks)

QUESTION TWO (20 MARKS)

(a) (i) Briefly explain the relationship, if any, between DTFT,DFT, FFT and Z transforms

(ii) Determine the four-point DFT of $x[n]$ of length $N = 4$ which is defined by the expression

$$x[n] = \begin{cases} 2 & n = 0 \\ 3 & n = 1 \\ -1 & n = 2 \\ 1 & n = 3 \end{cases}$$

(10 marks)

(b) (i) State three properties of the region of convergence (ROC)

(ii) The transfer function of an LTI system is

$$H(z) = \frac{z}{(z-0.75)(z+0.5)}$$

I. For each possible region of convergence, find the corresponding impulse response of the system

II. State the ROC where the system is causal and the ROC for which it is stable

(10 marks)

QUESTION THREE (20 MARKS)

(a) Distinguish between decimation-in-time and decimation in frequency as used in FFT

(2 marks)

(b) (i) Write down the equations for the decimation-in –time algorithm for N=4

(ii) Draw the signal flow graph corresponding to (i)

(iii) Use the flow graph of (ii) to compute DFT {1,1,1,1,}

(10 marks)

(c) By means DFT and IDFT, determine the response of the FIR filter with impulse response

$$h(n) = \{\underset{\uparrow}{\underbrace{1}}, 2, 3\}$$

to the input sequence

$$x(n) = \{\underset{\uparrow}{\underbrace{1}}, 2,2,1\}$$

QUESTION FOUR (20 MARKS)

(a) Given that $h(n) = \{1,0,1\}$ and $h(n) = \{1, 3, 2, -3 ,0 ,2, -1, 0, -2, 3, -2, 1, . .\}$, convolve the two sequences by using the following methods

i. Overlap and add;

ii. Overlap and save;

(10 marks)

(b) Obtain the direct form I, direct form II, cascade and parallel structures for the following systems:

$$(i)\ y(n) = \tfrac{1}{2}y(n-1) + \tfrac{1}{4}y(n-2) + x(n) + x(n-1)$$

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

(10 marks)

QUESTION FIVE (20 MARKS)

(a) Outline **five** steps involved in the design of an **FIR** filter

(5 marks)

(b) A continuous filter has a transfer function of

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

Design an equivalent digital filter using bilinear transform. It is important that the gain is preserved at the upper breakpoint frequency of 2 rad/s.The sampling frequency used is 2 Hz.

(10 marks)

(c) (i) State the Nyquist sampling theorem.

(ii) An analog signal is given by $x_a(t) = 3\cos 2000\,\pi t + 5 sin 6000\pi t + 10 cos 12000\pi t$

For this signal:

I. state the Nyquist rate

II. determine the discrete signal obtained after sampling for a sampling rate of $F_s = 5000$ samples/s

(5 marks)