TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATION 2017/2018

DEGREE OF BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONIC ENGINEERING)

EEE 2519: DIGITAL FILTERS

SPECIAL/SUPPLEMENTARY EXAMINATION

SERIES: SEPTEMBER 2018

TIME: 2 HOURS

DATE: Sep 2018

Instructions to Candidates

You should have the following for this examination

-*Answer Booklet, examination pass and student ID*

This paper consists of FIVE questions. Attempt **Question ONE (Compulsory)** and any other **TWO Questions**

Do not write on the question paper.

Question ONE (Compulsory)

a. Determine the fundamental frequency of the periodic sequence

$$x(n) = e^{j\frac{\pi}{16}n} cos\frac{n\pi}{17}$$

(3 marks)

b. Using the z-transform methods, determine the explicit expression for the output $y(n)$ for the causal LTI discrete time system with impulse response $h(n) = (-0.4)^n u(n)$ when the input is $(n) = (0.2)^n u(n)$, where $u(n)$ is the unit step sequence. (8 marks)

c. The impulse response of an LTI discrete system is given by $h(k) = 0.5^k u(k)$. Determine the output of the system for the input sequence $x(k) = \delta(k-1) + 3\delta(k-2) + 2\delta(k-6)$.

(7 marks)

d. A discrete-time system has the transfer function given by

$$H(z) = \frac{4 + \frac{9}{4}z^{-1} - \frac{1}{4}z^{-2}}{1 + \frac{1}{4}z^{-1} - \frac{1}{8}z^{-2}}$$

Implement the system as a

i. Direct form II canonic realization structure
ii. Parallel network of first order direct structures. (12 marks)

Question TWO

a. The response of a particular linear-shift invariant system to a unit step is given by:

$s(n) = n(\frac{1}{2})^n u(n)$

Determine the response of the same system to a sequence $a(n) = \begin{cases} 1, & n = 0 \\ 0, & else \end{cases}$ (3 marks)

b. Consider the interconnection of a linear shift invariant system given in Figure Q2(b)

where, $h_1(n) = \delta(n-1)$ and $H_2(e^{j\omega}) = \begin{cases} 1, & |\omega| \leq \frac{\pi}{2} \\ 0, & \frac{\pi}{2} < |\omega| < \pi \end{cases}$

For the system find

i. The unit sample response, and
ii. The frequency response. (10 marks)

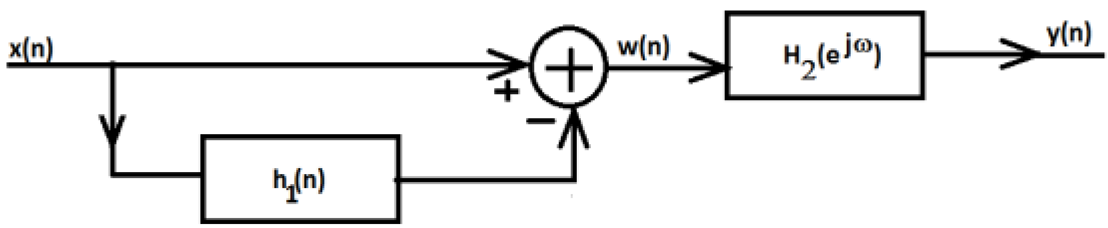

Figure Q2(b)

c. A digital filter implemented on a DSP may be described using the following difference equation $y(n) = 0.75y(n-1) - 0.125y(n-2) + x(n)$

When measuring the unit sample response of the system, the registers are not initialized to zero causing the output of the filter to be dependent on $y(-1) = -1$ and $y(-2) = 1$. Solve for the system response i.e., $y(n)$. (7 marks)

Question THREE

a. Consider a discrete-time IIR system represented by the difference equation

$y[n] = 0.5y[n-1] + x[n]$

with $x[n]$ as the input and $y[n]$ as the output. Determine:

i. the transfer function of the system and
ii. the impulse and the unit-step responses
iii. whether the system is BIBO stable or not. (7marks)

b. Obtain an expression for the transfer function $H(z) = \frac{Y(z)}{X(z)}$ for the Figure Q3(b). Hence, derive expressions for the magnitude and phase frequency responses for the system. (7 marks)

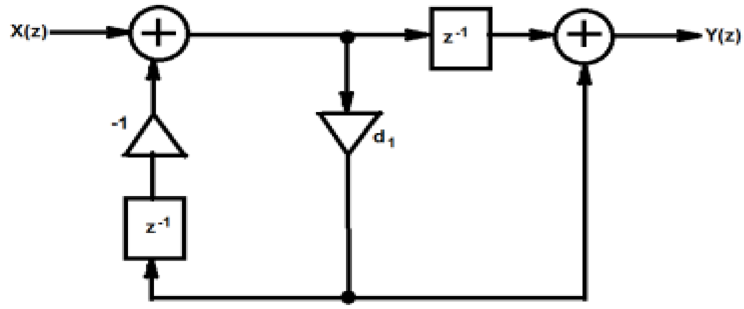

Figure Q3(b)

c. Determine the overall impulse response of the LTI system shown in figure Q3(c) given that
$h_1(n) = 2\delta(n-2) - 3\delta(n+1)$,
$h_2(n) = \delta(n-1) - 2\delta(n+2)$ and
$h_3(n) = 5\delta(n-5) + 7\delta(n-3) + 2\delta(n-1) - \delta(n) + 3\delta(n+1)$ (6 marks)

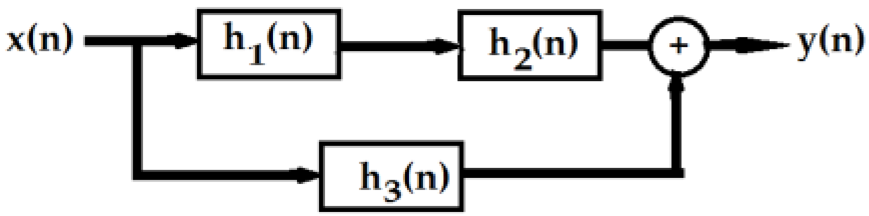

Figure Q3(c)

Question FOUR

a. A moving average filter is given by

$$y(n) = \frac{1}{M}\sum_{k=0}^{M-1} x(n-k)$$

where $x(n)$ is the input and $y(n)$ is the output.

i. Show that the filter is BIBO stable.
ii. Determine whether the filter is a linear time invariant system.
iii. Obtain the expression for the magnitude and phase frequency response of the moving average filter (15 marks)

b. Show that the bilinear transformation maps the $j\Omega$ axis in the s −plane onto the unit circle, i.e., $|z| = 1$, and maps the left-half s −plane inside the unit circle, i.e., $|z| < 1$.

(5 marks)

Question FIVE

a. You are to design a lowpass FIR filter using the window method to meet the following specifications:

The passband edge frequency $\omega_p = 0.3\pi$

The stopband edge frequency $\omega_s = 0.5\pi$

The minimum stopband attenuation $\alpha_s = 40\ dB$

Determine

i. The order of the filter,

ii. The impulse response of the ideal LPF $h(n)$,

iii. The appropriate window function, and

iv. The first three of the truncated impulse response coefficients.

(10 marks)

b. A bandpass Butterworth IIR digital filter is to be designed using the bilinear z-transform method to meet the following specifications:

- The passband-edge frequencies: 2kHz and 4 kHz
- The stopband-edge frequencies: 1.8 kHz and 4.5 kHz
- The maximum passband attenuation: 0.5 dB
- The minimum stopband attenuation: 40 dB
- The sampling frequency is to be 10 kHz.

i. Obtain the specifications of the corresponding analog bandpass filter. To obtain geometric symmetry adjust the lower passband edge frequency of the bandpass filter.

ii. Give the specifications of the prototype lowpass filter to be used in the design.

iii. Write a MATLAB programme that will compute coefficients of the desired digital filter starting with the prototype lowpass filter. (10 marks)