# BACHELOR OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING EXAMINATION, 2019

## (3rd Year, 2nd Semester)

## DIGITAL SIGNAL PROCESSING

**Time: Three Hours** **Full Marks: 100**

**(Answer Any Five Questions)**

1. (a) Determine whether the following signal is periodic or not. If periodic, find its fundamental period

$$x(n) = \cos(\left(\frac{5\pi}{9}\right).n + 1)$$

(b) Find the even and odd components of the following signal.

$$x(n) = \{-3, 1, \underset{\uparrow}{2}, -4, 2\}$$

(c) Check the linearity and time-invariance of the following system.

$$T[x(n)] = n.x(n)$$

(d) Find the convolution of the following.

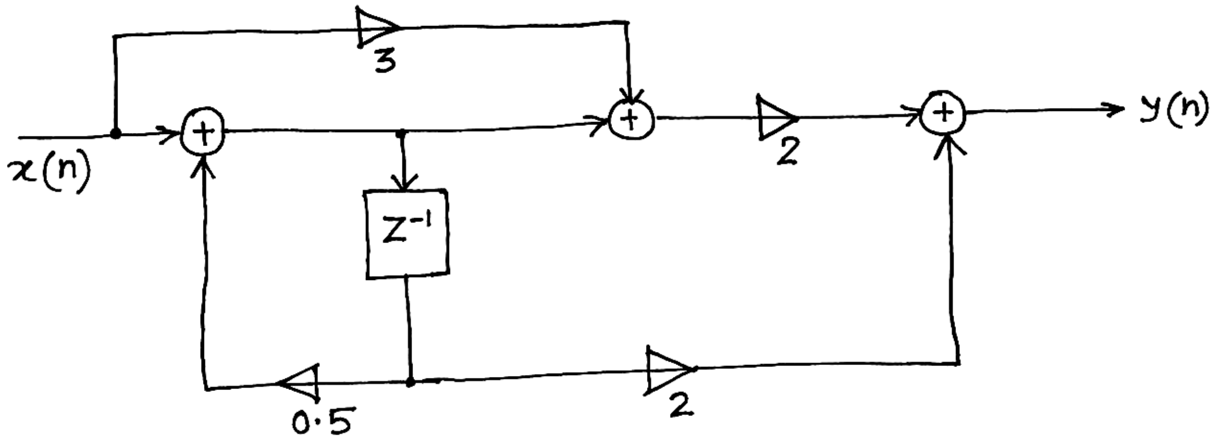
$$x(n) = \{2, \underset{\uparrow}{1}, 2, 1, 1\}$$

$$h(n)=\{\underset{\uparrow}{1}, 0, 1, 1\}$$

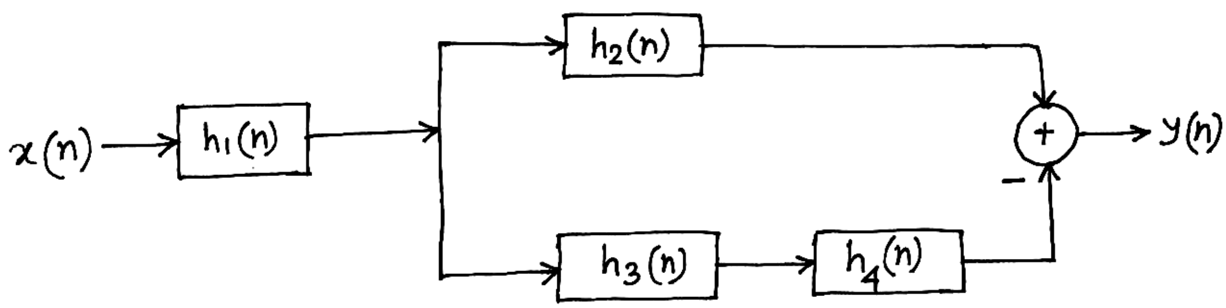
(e) Check the causality and BIBO stability for the following.

$$h(n)= \left(-\frac{1}{2}\right)^n u(n)$$ (5×4)

2. (a) Determine the system function, difference equation and the impulse response of the following system.




(b) Consider the interconnection of LTI systems as shown ~~in~~ below.




(i) Express the overall impulse response in terms of $h_1(n)$, $h_2(n)$, $h_3(n)$ and $h_4(n)$.

(ii) Determine h(n) when

$h_1(n) = \{\frac{1}{2}, \frac{1}{4}, \frac{1}{2}\}$

$h_2(n) = h_3(n) = (n+1)u(n)$

$h_4(n) = \delta(n-2)$

(10+10)

3. (a) An FIR filter is described by the difference equation

$$y(n)=x(n) - x(n-6)$$

(i) Compute and sketch its magnitude and phase response.

(ii) Determine its response to the following input.

$$x(n) = 5 + 6\cos\left(\frac{2\pi}{5}.n + \frac{\pi}{2}\right), \quad -\infty < n < \infty$$

(b) Consider the filter.

$$y(n) = 0.9\,y(n-1) + b\,x(n)$$

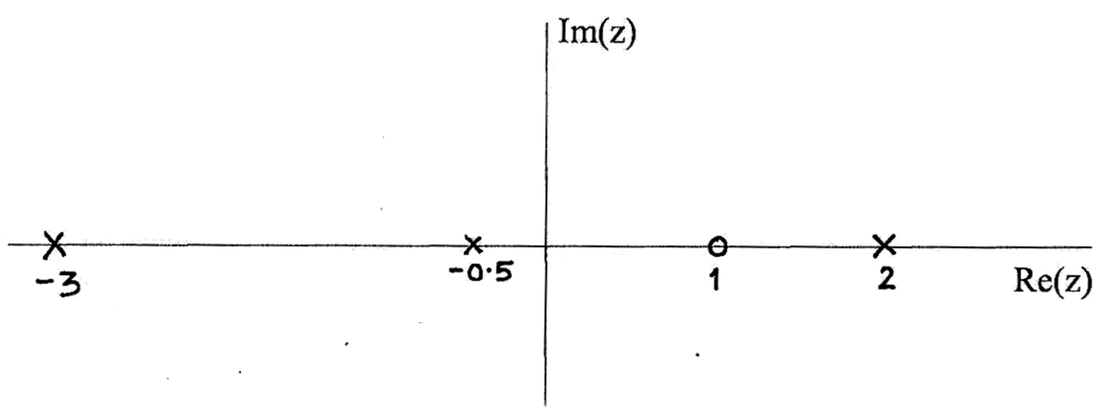
(i) Determine b so that $H(e^{j\omega})|\ \omega_{=0}=1$.
(ii) Determine the 3dB cut-off frequency.
(iii) Is this filter lowpass, bandpass or highpass?
(iv) Repeat parts (ii) and (iii) for the filter.

$$y(n) = -0.9y(n-1) + 0.1\,x(n)$$

(10+10)

4. (a) Consider an LTI discrete-time system whose pole- zero pattern is shown below.

(i) Determine the ROC of the system function H(z), if the system is known to be stable.
(ii) Is it possible for the given pole- zero plot to correspond to a causal and stable system? If so, what is the appropriate ROC?
(iii) How many possible systems can be associated with this pole-zero pattern?




(b) Design a 4-tap high pass linear phase FIR filter with an antisymmetric impulse response for which amplitude frequency response at $\omega = \frac{\pi}{4}$ *and* $\omega = \frac{3\pi}{4}$ is given by $\frac{1}{2}$ and 1 respectively.

(10+10)

[TURN OVER]

5. (a) Design a 3-tap FIR low pass filter with cut-off frequency of 800 Hz and a sampling rate of 8000 Hz using the Hamming window method. Determine the system function.

(b) Design an FIR notch filter to remove an undesirable 60-Hz hum associated with a power supply in an ECG recording application. The sampling frequency used is $F_s$=500 samples/s. How can you obtain an improved version of the designed notch filter?

(12+ 8)

6. (a) Consider the following system:

$$y(n)=a\,y(n-1) - a\,x(n) + x(n-1).$$

(i) Show that it is allpass.
(ii) Obtain the direct form-II realization of the system.
(iii) Obtain the corresponding lattice realization of the system.

(b) Derive and sketch the cascade and parallel structures for the system with the following system function.

$$H(z) = \frac{0.5(1-z^{-2})}{1+1.3z^{-1}+0.36z^{-2}}$$

(10+10)

7. (a) Use the four-point DFT and IDFT to determine the sequence

$x_3(n)= x_1(n) \text{ Ⓝ } x_2(n)$

where $x_1(n)$ and $x_2(n)$ are the sequences given below.

$$x_1(n) = \{1, 2, 3, 1\}$$
$$\uparrow$$

$$x_2(n)=\{4, 3, 2, 2\}$$
$$\uparrow$$

(b) Design a digital low pass Butterworth filter to satisfy the following constraints.

$$0.9 \le |H(e^{j\omega})| \le 1, \qquad 0 \le \omega \le 0.2\pi$$

$$|H(e^{j\omega})| \le 0.2, \qquad 0.4\pi \le \omega \le \pi$$

Use bilinear transformation and consider a sampling interval, $T_s$ of 1 second

(8+12)

8. (a) Consider the recursive discrete- time system described by the difference equation .

$$y(n) = - a_1 y(n-1) - a_2 y(n-2) + b_0 x(n)$$

Where $a_1 = -0.8$, $a_2 = 0.64$ and $b_0 = 0.866$

Write a MATLAB program to compute and plot

i) Pole-zero pattern of the system.
ii) Impulse response h(n) of the system for $0 \leq n \leq 49$.
iii) Frequency response of the system for $0 \leq \omega \leq \pi$.

(b) Draw the block diagram of the hardware architecture of TMS 320C6713 Digital Signal Processor and explain its functionality.

(10+10)

9. Discuss in details any practical application of Digital Signal Processing.

(20)