Midterm Examination – EE092IU

Date: November 6^{th}, 2018

Duration: 90 minutes

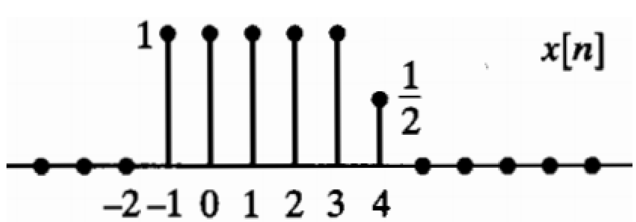
SUBJECT: **DIGITAL SIGNAL PROCESSING – EE092IU**	
Dean of School of Electrical Electronics Engineering Signature: Full name:	Lecturer: Prof. Dr. Thuong Le-Tien (Cell : 0903 787 989) Signature: Full name: THUONG LE-TIEN

INSTRUCTION:

- One A4 page of notes is allowed in the exam
- Answer 4 from 5 following questions

Question 1: (25 Marks)

A discrete time signal x(n) is given in the figure



Sketch and label carefully each of the following signals:

a. x(n-2)
b. x(4-n)
c. x(2n)
d. x(n)u(2-n)

Question 2: (25 Marks)

The analog signal $x(t)=\sin(8\pi t)[-2\cos(8\pi t) +2\cos(3\pi t)]$, where t is in milliseconds, is sampled at a rate of 12kHz. The resulting samples are immediately reconstructed by an ideal reconstructor.

a. Find and sketch the spectrum of x(t) versus Ω.
b. Find and sketch the spectrum of the sampled signal versus ω.
c. Determine the analog signal $x_a(t)$ at the output of the reconstructor.
d. Prove the x(t) and $x_a(t)$ having the same samples after sampling with a rate of 12kHz?

Question 3: (25 Marks)

Consider an LTI system with the frequency response

$$H(e^{j\omega}) = e^{-j(\omega-\frac{\pi}{4})}\left(\frac{1+e^{-j2\omega}+4e^{-j4\omega}}{1+0.5e^{-j2\omega}}\right), \quad -\pi < \omega \leq \pi$$

Determine the output y(n) for all n if the input for all n is: $x(n)=\cos(0.5\pi n)$

Question 4: (25 Marks)

Consider the following sound wave, where t is in milliseconds:

$$x(t) = \sin(50\pi t)[-2\cos(30\pi t) +2\cos(80\pi t)],$$

This signal is prefiltered by an analog antialiasing prefilter H(f) and then sampled at an audio rate of 40 kHz. The resulting samples are immediately reconstructed using an ideal reconstructor (a lowpass filter with cut-off frequency 20kHz). Determine the output $y_a(t)$ of the reconstructor in the following cases

a. When the response of the prefilter is $H(f) \equiv 4$ (i.e. the prefilter is an amplifier)
b. When H(f) is an ideal prefilter with cut off of 50 kHz, gain is 1.
c. When H(f) is a practical prefilter that has a flat passband up to 20 kHz, gain is 1 and attenuates at a rate of 60dB/octave beyond 20 kHz.

Question 5: (25 Marks)

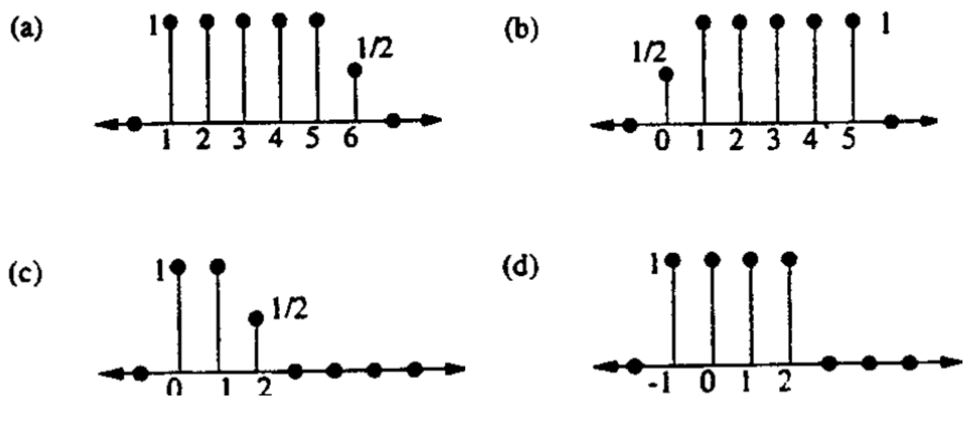
Consider a 4-bit successive approximation AD converter with full scale range of 5volts. Using the rounding technique, determine the 4-bit codes of the voltage values x = 2.3; -1.4; 0.76; -0.4; 2.19; -0.91 volts, for the following types of converters:

a. Write the code table for converting the samples of full scale range of 5 volts with the natural binary, the offset and the two's complement codes.
b. Write a table for converting the values of x into the Natural binary codes, the offset and the two's complement codes

Good lucks!

SOLUTIONs

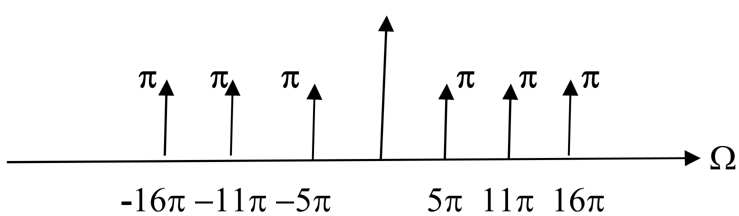
Question 1



Question 2

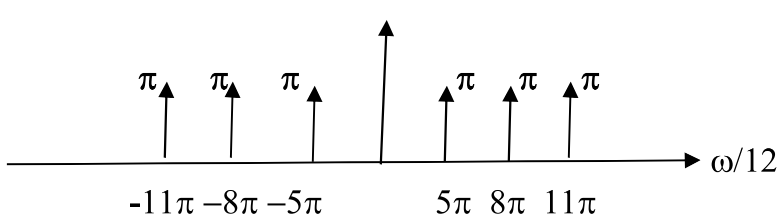
a) $x(t) = -\sin(16\pi t) + \sin(11\pi t) + \sin(5\pi t)$

$X(\Omega) = j\pi\,[\delta(\Omega-16\pi) - \delta(\Omega+16\pi)] + j\pi\,[\delta(\Omega+11\pi) - \delta(\Omega-11\pi)] + j\pi\,[\delta(\Omega+5\pi) - \delta(\Omega-5\pi)]$



b) $x(nT) = \sin(8\pi n/12) + \sin(11\pi n/12) + \sin(5\pi n/12)$

$X(\omega) = j\pi\,[\delta(\omega+11\pi/12) - \delta(\omega-11\pi)] + j\pi\,[\delta(\omega+8\pi/12) - \delta(\omega-8\pi/12)] + j\pi\,[\delta(\omega+5\pi/12) - \delta(\omega-5\pi/12)]$



c. The reconstructed signal

$$x_a(t) = \sin(8\pi t) + \sin(11\pi t) + \sin(5\pi t)$$

d. It is easy to check the x(t) and $x_a(t)$ have the same samples after sampling

Question 3

$x(n) = \cos(\pi n/2) = 1/2[e^{j\pi n/2} + e^{-j\pi n/2}]$
then the output $y(n) = x(n)H(\pi/2) = 8e^{j\pi/4}\cos(\pi n/2-\pi/2)$

Question 4

a. $y_a(t) = -4\sin(20\pi t) - 8\sin(30\pi t)$
b. All frequency components with f>50Hz are filtered out after passing through the prefilter then $y_a(t) = -\sin(20\pi t) - \sin(30\pi t)$
c. $y_a(t) = -\sin(20\pi t) - \sin(30\pi t) - (1/125{,}893)\sin(30\pi t)$

Question 5

a. Write the code table for three Natural, offset and 2'complement codes as the lecture notes
b. Table for converted codes

x(n)	$x_Q(n)$	Natural code	Offset Code	2's Complement
2.3	2.1875	0111	1111	0111
-1.4	-1.25	N/A	0100	1100
0.76	0.625	0010	1010	0010
-0.4	-0.3125	N/A	0111	1111
2.19	2.1875	0111	1111	0111
-0.91	-0.9375	N/A	0101	1101