Electrical Engineering Department | **4th Year Communications.**
Digital Signal Processing | **Allowed Time: 3 Hrs.**
Final Exam | **Date: 31- December-2013.**

Answer the following questions:

1- Signal Manipulation and Discrete Systems [25 Marks].

A. Determine whether or not the signal below is periodic and if it is periodic determine the fundamental period [3 Marks]:

$$x(n) = \cos(\frac{n\pi}{8}) + \mathrm{Re}[e^{\frac{jn\pi}{12}}] + \mathrm{Im}[e^{\frac{jn\pi}{18}}]$$

B. A sinusoidal signal x(t) = Cos(wt) is sampled at the Nyquest rate starting at (wt = 0) (the signal frequency is 10 kHz) find [7 Marks]:

- **b.1. Sampling frequency.**
- **b.2. Draw x(n) [at least 2 cycles].**
- **b.3. Draw the delayed version of x(n) by 3 samples.**
- **b.4. Draw the compressed version of x(n) by a factor of 2.**

C. A linear discrete time system is characterized by its response [4 Marks]:

$$h_k(n) = (n-k)\,u(n-k)$$

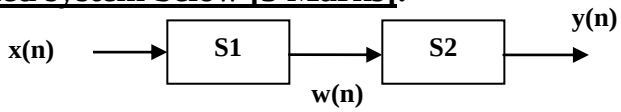
Determine whether or not this system is:

- **c.1. Stable.**
- **c.2. Causal.**

D. Determine if the following system is invertible or not ? [2 Marks]

$$y(n) = n^2\,x(n)$$

E. Consider the cascaded system below [3 Marks]:



If both S1 and S2 are Shift Varying will the Cascade be Shift Varying also (with Example)

F. For the input signal x(n) to the system of the response h(n) [6 Marks]:

$$h(n) = u(-n-1) \quad \text{and} \quad x(n) = -n\,3^n\,u(-n)$$

- **f.1. Draw x(n) and h(n).**
- **f.2. Convolve x(n) with h(n).**

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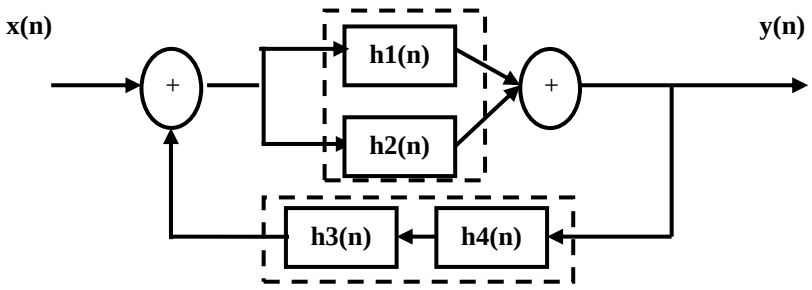
2- Fourier Analysis [30 Marks]

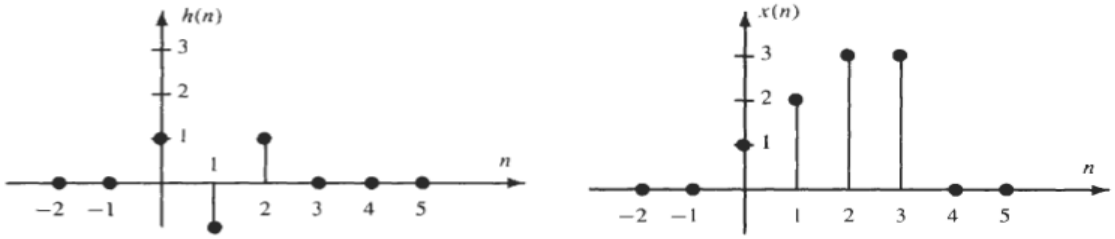
A. For the feedback system shown in the fig below find $H(e^{jw}) = Y(e^{jw})/X(e^{jw})$ [5 Marks]



B. Find the DTFT for: [5 Marks]

$$x(n) = a^n \text{ Sin } (nw_0)\, u(n)$$

C. Find the 4 point Circular Convolution of h(n) with x(n) shown below: [10 Marks]



D. Let $x_a(t)$ be a periodic continuous time signal: [5 Marks]

$$x_a(t) = A \text{ Cos } (500\pi t) + B \text{ Cos } (200\pi t)$$

That is sampled at 1 kHz find the DFS coefficients of the sampled signal.

E. Find the N point DFT for: [5 Marks]

$$x(n) = 10 + 2\text{Cos}^2 (\pi n/N) \qquad n = 0,1,2, \ldots.$$

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3- Fast Fourier Transform and Z Transform [20 Marks]

A. Explain in details the Radix2 FFT Algorithm showing the decimation in time and how it can reduce the processing time of the DFT. [10 Marks]

B. Speech signal is limited to 4 kHz and sampled at the Nyquest rate is to be processed in real time for the 4th Generation of the mobile communication (LTE), part of the computation is the speech coding that uses a Segment of voice (20 ms block) it must then be processed using DFT and IDFT (using FFT), the time required for each complex multiplication is 1 micro Sec find: [5 Marks]

b.1. Number of samples per speech segment.

b.2. How much time is required for both DFT and IDFT.

b.3. How much time is remaining for further computation in the system.

C. Find the Z – Transform for [5 Marks]

$$x(n) = -a^n u(-n-1)$$

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$\sum_{n=0}^{N-1} a^n = \frac{1-a^N}{1-a}$	$\sum_{n=0}^{\infty} a^n = \frac{1}{1-a} \quad \lvert a\rvert < 1$
$\sum_{n=0}^{N-1} na^n = \frac{(N-1)a^{N+1} - Na^N + a}{(1-a)^2}$	$\sum_{n=0}^{\infty} na^n = \frac{a}{(1-a)^2} \quad \lvert a\rvert < 1$
$\sum_{n=0}^{N-1} n = \frac{1}{2}N(N-1)$	$\sum_{n=0}^{N-1} n^2 = \frac{1}{6}N(N-1)(2N-1)$

Good Luck

Dr. Michael Nasief