EE113 Digital Signal Processing

Spring 2019

Homework 3

Due: Wednesday, April 22 at 12pm

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April 15, 2019

Total: 100 points

Problem 1. ***(25 points) (Use MATLAB for part (c) of this problem)*** *Consider the DTLTI system shown in Fig. 1:*

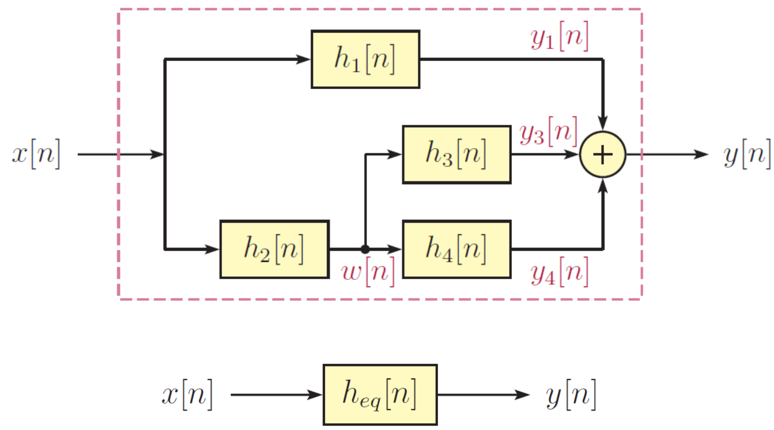


Figure 1: System Block diagram for Problem 5

(a) ***(5 points)*** *Express the impulse response of the system as a function of the impulse responses of the subsystems.*

(b) ***(10 points)*** *Let*

$$h_1[n] = e^{-0.1n}u[n]$$
$$h_2[n] = h_3[n] = u[n] - u[n-3]$$

and

$$h_4[n] = \delta[n-2]$$

Determine the impulse response $h_{eq}[n]$ of the equivalent system. Note that you need to do the convolution on paper, but are free to use MATLAB ("conv" command) to verify if your calculations are correct.

(c) ***(10 points)*** *Let the input signal be a unit-step, that is, $x[n] = u[n]$. Determine and plot $y[n]$ in MATLAB.*
(Include the MATLAB plots for $n = 0, 1, \ldots, 10$ samples only, and use "stem" for the plot command)

Problem 2. ***(20 points)*** *Impulse response problems:*

(a) ***(10 points)*** *The response of a linear time-invariant system to $x[n] = u[n]$ is $y[n] = 0.5^n u[n]$. Find its response to $\delta[n]$.*

(b) ***(10 points)*** *True or False: If both the input sequence to an LTI system and its impulse response sequence are even sequences, then the output sequence is also even.*

Problem 3. ***(20 points)*** *Evaluate the convolutions:*

(a) ***(10 points)*** $u[n] * \left(\frac{1}{2}\right)^n u[n-1]$.

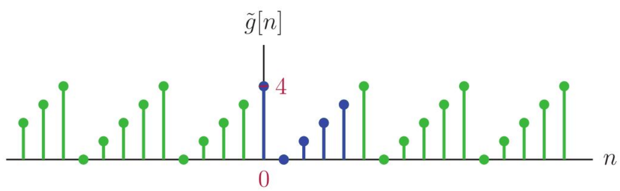
(b) ***(10 points)*** $u[-n] * \left(\frac{1}{2}\right)^n u[n-1]$.

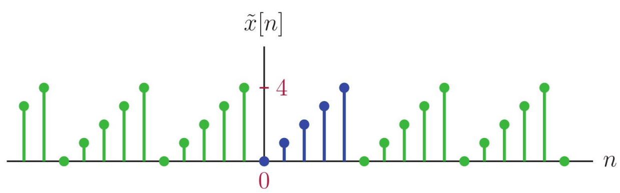
Problem 4. ***(15 points)*** *Determine the DTFS representation of the signal*

$$x[n] = 1 + \cos(0.24\pi n) + 3\sin(0.56\pi n)$$

Assume that the period of $x[n]$ is the LCM of the periods of the sinusoidal terms. Sketch the DTFS spectrum. Note that if the DTFS coefficients are complex, you need to plot the magnitude and the phase of the coefficients separately.

Problem 5. ***(20 points)*** *Consider the periodic signal $\tilde{g}[n]$ in the following figure. $\tilde{g}[n]$ is a delayed version of the signal $\tilde{x}[n]$ also shown below.*





(a) ***(10 points)*** *Determine the DTFS coefficients of $\tilde{g}[n]$, denoted by $\tilde{d}_k$, $k = 0, ..., 4$ directly from the DTFS analysis equation:*

$$\tilde{d}_k = \frac{1}{N} \sum_{n=0}^{N-1} \tilde{g}[n] e^{-j(2\pi/N)kn}.$$

You are free to use MATLAB for calculations (addition/multiplication of complex numbers, for example). Alternately you can also leave the final expression as a summation of complex exponential terms.

(b) ***(10 points)*** *Determine the DTFS coefficients $\tilde{d}_k$, $k = 0, ..., 4$ by applying the time shifting property to the coefficients of $\tilde{x}[n]$. The coefficients of $\tilde{x}[n]$, denoted by $\tilde{c}_k$ are given in the table below. You are free to use MATLAB for calculations (addition/multiplication of complex numbers, for example).*

k	$\tilde{c}_k$
0	$2.0000 + j\,0.0000$
1	$-0.5000 + j\,0.6882$
2	$-0.5000 + j\,0.1625$
3	$-0.5000 - j\,0.1625$
4	$-0.5000 - j\,0.6882$