GEORGIA INSTITUTE OF TECHNOLOGY

SCHOOL of ELECTRICAL and COMPUTER ENGINEERING

EE 2200 Winter 1999
Problem Set #7

Assigned: 4 March 99
Due Date: 12 March 99 (FRIDAY)

Final Exam is scheduled for Period #11: 18-March (Thursday) at 11:30AM. In the ECE Auditorium.

Review Session is planned for Wednesday evening of Finals week. More details later.

Reading: In *DSP First*, Chapters 7 and 8 on *Z-Transforms* and *IIR Filters.*

$\Longrightarrow$ The four (4) **STARRED** problems will have to be turned in for grading.

Next week a solution will be posted. Some similar problems solutions can be found on the CD-ROM and in old homeworks, especially the "unstarred" problems.

PROBLEM 7.1*:

A linear time-invariant system has system function

$$H(z) = (1 + z^{-2})(1 - z^{-1} + z^{-2})$$

(a) Determine the impulse response of this system.

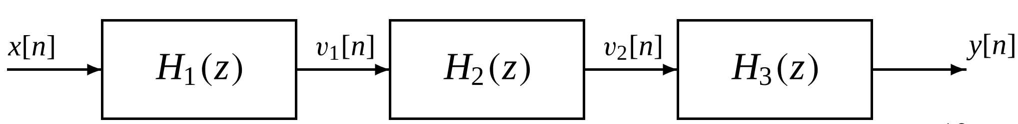
(b) The input to this system is

$$x[n] = 3 + 99\delta[n] + 20\cos(\pi n/3)$$

Determine the output of the system $y[n]$ corresponding to the above input $x[n]$. Give an equation for $y[n]$ that is valid for all n. (*Note: This is an easy problem if you approach it correctly!*)

PROBLEM 7.2:

In the following cascade of systems, all of the individual transfer functions are known.



$$H_1(z) = z^{-2} + z^{-3} \qquad H_2(z) = 4 - 3z^{-1} \qquad H_3(z) = \frac{10}{8 - 10z^{-1} + 3z^{-2}}$$

(a) Determine $H(z)$ the z-transform of the cascaded system. Simplify $H(z)$ by cancelling common factors in the numerator and denominator.

(b) Consider the impulse response of the cascaded system, i.e., the response $y[n]$ when the input is $x[n] = \delta[n]$. Prove that the impulse response has the form $h[n] = G\,\alpha^n$ for $n \geq 3$. Find values for α and G.

PROBLEM 7.3:

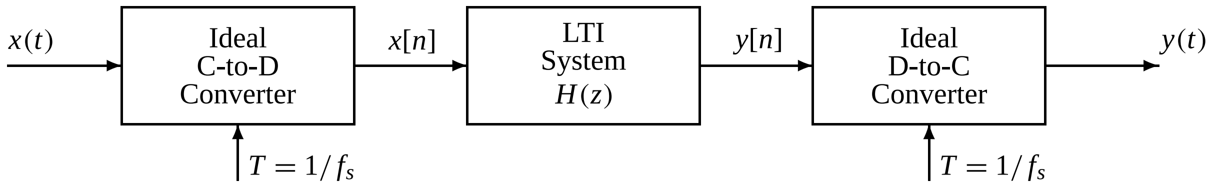
The input to the C-to-D converter in the figure below is

$$x(t) = 3 + 2\cos(6000\pi t - \pi/4) + 11\cos(12000\pi t - \pi/3)$$

The system function for the LTI system is

$$H(z) = \frac{1}{4}(1 - z^{-4})$$

If $f_s = 8000$ samples/second, determine an expression for $y(t)$, the output of the D-to-C converter.



PROBLEM 7.4*:

For each of the systems below determine the poles and zeros and also draw a pole-zero diagram.

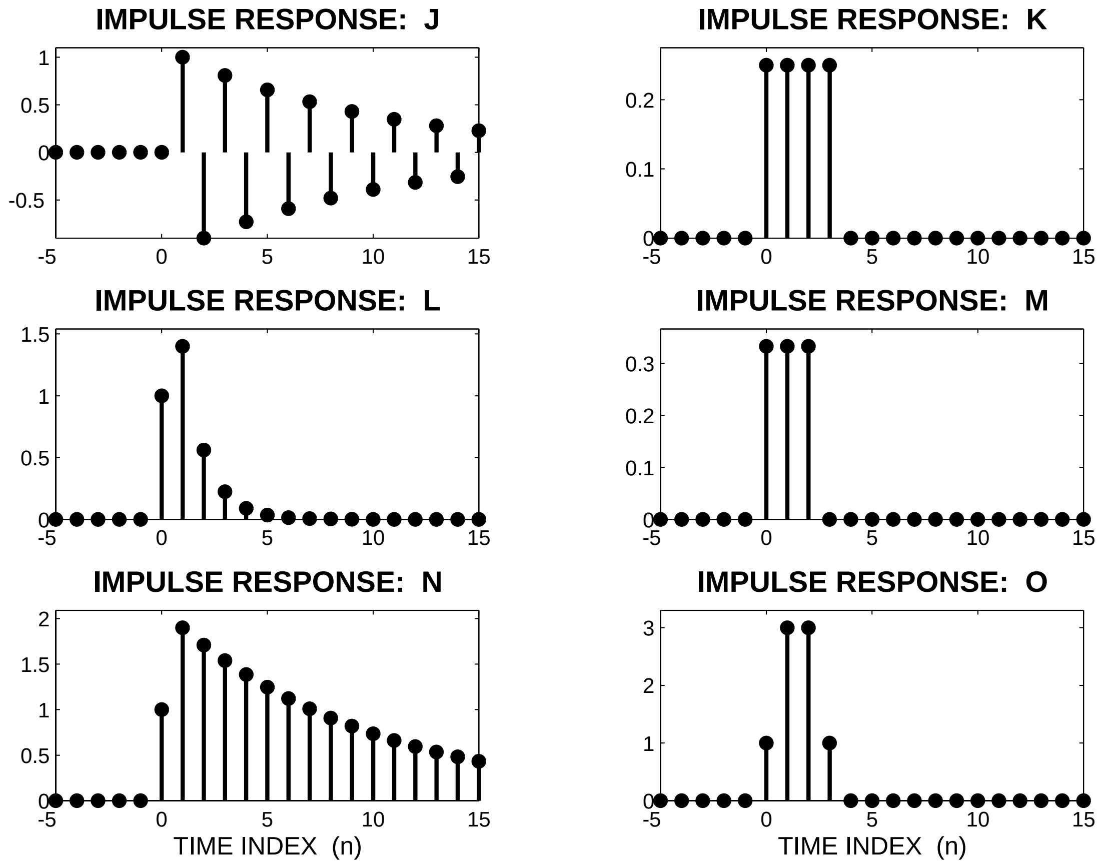
$$S_1: \qquad H(z) = \tfrac{1}{3}(1 + z^{-1} + z^{-2})$$

$$S_2: \qquad H(z) = \frac{1 - z^{-5}}{5(1 - z^{-1})}$$

$$S_3: \qquad y[n] = 0.4y[n-1] + x[n] + x[n-1]$$

$$S_4: \qquad H(z) = \frac{z^{-1}}{1 + 0.9z^{-1}}$$

PROBLEM 7.5*:



For each of the systems below (specified by either an $H(z)$ or a difference equation), derive the impulse-response formula, and then determine which of plots (J, K, L, M, N, O) matches each system.

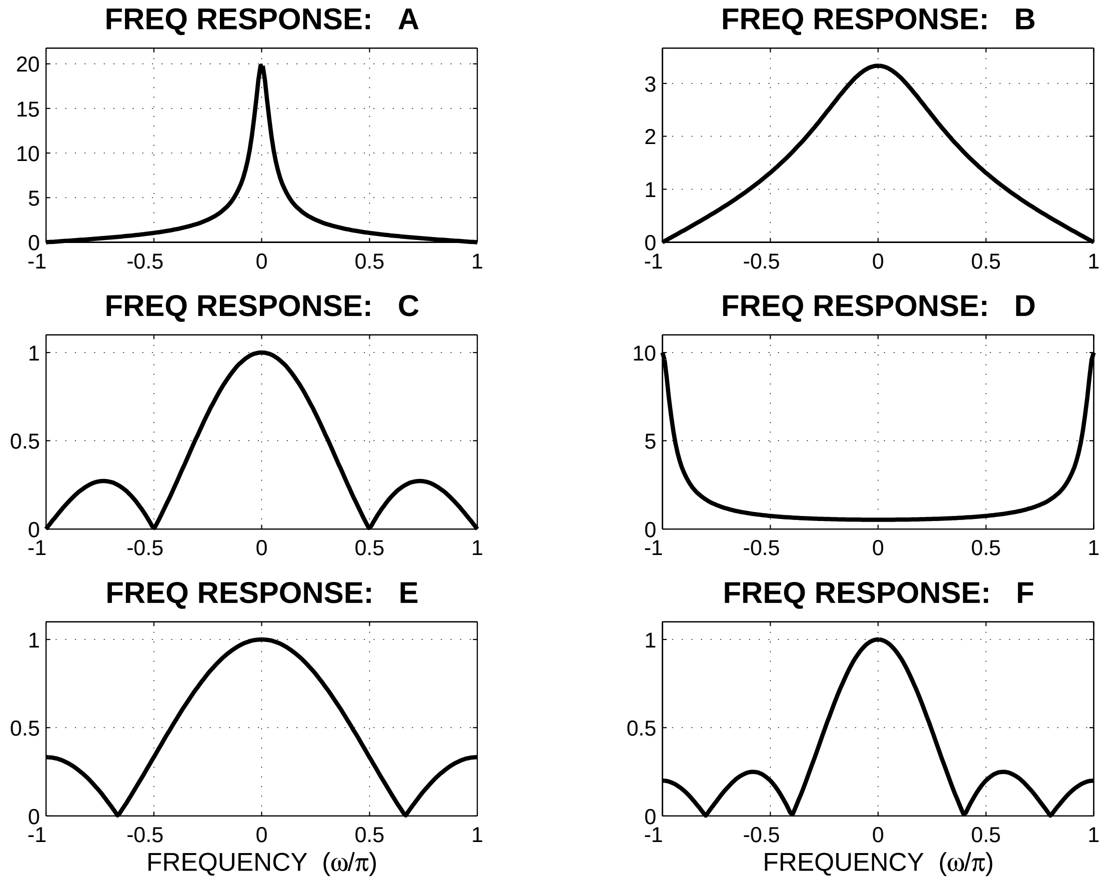
$$S_1: \qquad H(z) = \tfrac{1}{3}(1 + z^{-1} + z^{-2})$$

$$S_2: \qquad H(z) = (1 + z^{-1})^3$$

$$S_3: \qquad y[n] = 0.4y[n-1] + x[n] + x[n-1]$$

$$S_4: \qquad H(z) = \frac{z^{-1}}{1 + 0.9z^{-1}}$$

PROBLEM 7.6*:



For each of the systems below (specified by either an $H(z)$ or a difference equation), derive the frequency response formula and then determine which of the magnitude plots (A, B, C, D, E, F), matches each system. NOTE: frequency axis is normalized; it is $\hat{\omega}/\pi$.

$$S_1: \qquad H(z) = \tfrac{1}{3}(1 + z^{-1} + z^{-2})$$

$$S_2: \qquad H(z) = \frac{1 - z^{-5}}{5(1 - z^{-1})}$$

$$S_3: \qquad y[n] = 0.4y[n-1] + x[n] + x[n-1]$$

$$S_4: \qquad H(z) = \frac{z^{-1}}{1 + 0.9z^{-1}}$$