



**PROBLEM Fall-04-Q.2.1:**

A periodic signal  $x(t)$  is given by

$$x(t) = 3 + 2 \cos(1000\pi t) + \cos(1500\pi t).$$

- (a) Determine the fundamental period of the signal  $x(t)$ , i.e., the minimum period.

$T_0 =$   sec. (Give a numerical answer.)

- (b) Let the  $k^{\text{th}}$  Fourier series coefficient of  $x(t)$  be  $a_k$ . Fill in the table below, giving *numerical values* for each requested  $\{a_k\}$  in polar form.

- (c) Now define

$$y(t) = x(t - 0.0005).$$

This signal can be expressed in the following Fourier Series with new coefficients  $\{b_k\}$

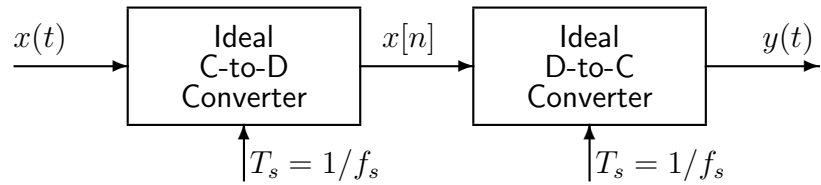
$$y(t) = \sum_{k=-\infty}^{\infty} b_k e^{j500\pi kt}.$$

Fill in the second table below, giving *numerical values* for each requested  $\{b_k\}$  in polar form.

$a_k$	Mag	Phase
$a_{-4}$		
$a_{-3}$		
$a_{-2}$		
$a_{-1}$		
$a_0$		
$a_1$		
$a_2$		
$a_3$		
$a_4$		

$b_k$	Mag	Phase
$b_{-4}$		
$b_{-3}$		
$b_{-2}$		
$b_{-1}$		
$b_0$		
$b_1$		
$b_2$		
$b_3$		
$b_4$		

**PROBLEM Fall-04-Q.2.2:**

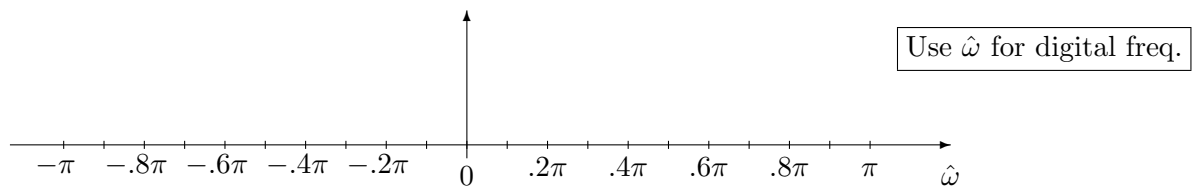


Suppose that the continuous-time input  $x(t)$  to the above system is given as

$$x(t) = \cos(16,000\pi t + \pi/4) + \cos(2000\pi t).$$

(a) Determine a  above which no aliasing of  $x(t)$  occurs.

(b) Given that  $f_s = 10,000$  samples/second,  the frequency spectrum for  $x[n]$ .



(c) Write a simplified expression for the  in terms of cosine functions.

### PROBLEM Fall-04-Q.2.3:

We have shown that an LTI system can be represented in several equivalent ways. In each part below, you are given one representation of an LTI system and you are to provide the other representations requested. (Frequency response formulas can be given in any convenient form. You do **NOT** have to simplify them.)

(a) Frequency response:

Impulse response:

Difference equation:  $y[n] = x[n] - x[n - 2]$

(b) Frequency response:  $H(e^{j\hat{\omega}}) = e^{-j\hat{\omega}}(-3 + 2\cos(\hat{\omega}))$

Impulse response:

Difference equation:

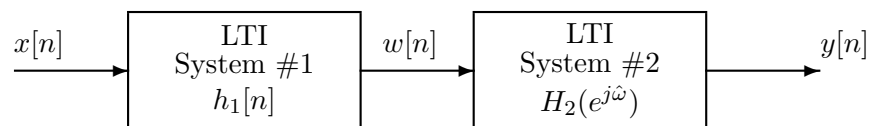
(c) Frequency response:

Impulse response:

MATLAB Implementation:  $y = \text{conv}([0, 2, 0, 2], x)$

**PROBLEM Fall-04-Q.2.4:**

Consider the following cascade system:



where

$$h_1[n] = \delta[n] - 2\delta[n - 1] + \delta[n - 2] \quad \text{and} \quad H_2(e^{j\hat{\omega}}) = \frac{1}{2} + e^{-j\hat{\omega}}$$

(a) Find and plot the impulse response  $h[n]$  of the overall system.

(b) Find the output signal  $y[n]$  if  $x[n] = \cos \pi n$ .

**PROBLEM Fall-04-Q.2.1:**

A periodic signal  $x(t)$  is given by

$$x(t) = 3 + 2 \cos(1000\pi t) + \cos(1500\pi t).$$

- (a) Determine the fundamental period of the signal  $x(t)$ , i.e., the minimum period.

$T_0 = \boxed{.004}$  sec. (Give a numerical answer.)

- (b) Let the  $k^{\text{th}}$  Fourier series coefficient of  $x(t)$  be  $a_k$ . Fill in the table below, giving *numerical values* for each requested  $\{a_k\}$  in polar form.

- (c) Now define

$$y(t) = x(t - 0.0005).$$

This signal can be expressed in the following Fourier Series with new coefficients  $\{b_k\}$

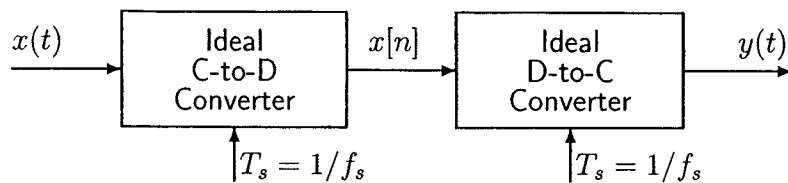
$$y(t) = \sum_{k=-\infty}^{\infty} b_k e^{j500\pi kt}.$$

Fill in the second table below, giving *numerical values* for each requested  $\{b_k\}$  in polar form.

$a_k$	Mag	Phase
$a_{-4}$	0	NA
$a_{-3}$	1/2	0
$a_{-2}$	1	0
$a_{-1}$	0	NA
$a_0$	3	0
$a_1$	0	NA
$a_2$	1	0
$a_3$	1/2	0
$a_4$	0	NA

$b_k$	Mag	Phase
$b_{-4}$	0	NA
$b_{-3}$	1/2	3π/4
$b_{-2}$	1	π/2
$b_{-1}$	0	NA
$b_0$	3	0
$b_1$	0	NA
$b_2$	1	-π/2
$b_3$	1/2	-3π/4
$b_4$	0	NA

**PROBLEM Fall-04-Q.2.2:**

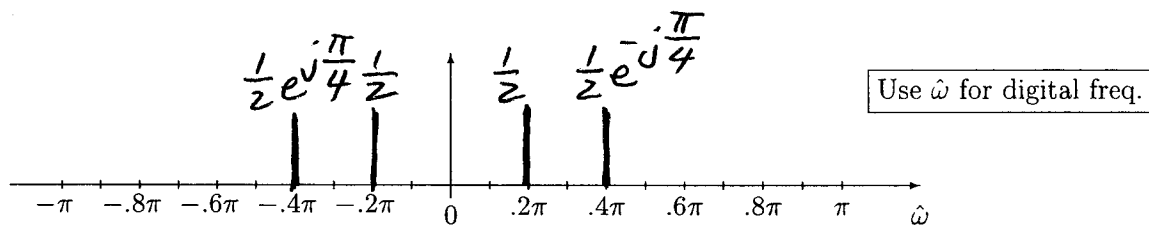


Suppose that the continuous-time input  $x(t)$  to the above system is given as

$$x(t) = \cos(16,000\pi t + \pi/4) + \cos(2000\pi t).$$

(a) Determine a sampling rate above which no aliasing of  $x(t)$  occurs.  $f_s = 16,000 \text{ Hz.}$

(b) Given that  $f_s = 10,000$  samples/second, plot the frequency spectrum for  $x[n]$ .



(c) Write a simplified expression for the output  $y(t)$  in terms of cosine functions.

$$y(t) = \cos(2000\pi t) + \cos(4000\pi t - \frac{\pi}{4})$$

**PROBLEM Fall-04-Q.2.3:**

We have shown that an LTI system can be represented in several equivalent ways. In each part below, you are given one representation of an LTI system and you are to provide the other representations requested. (Frequency response formulas can be given in any convenient form. You do NOT have to simplify them.)

(a) Frequency response:  $H(e^{j\hat{\omega}}) = 1 - e^{-j2\hat{\omega}}$

Impulse response:  $h[n] = \delta[n] - \delta[n-2]$

Difference equation:  $y[n] = x[n] - x[n-2]$

(b) Frequency response:  $H(e^{j\hat{\omega}}) = e^{-j\hat{\omega}}(-3 + 2\cos(\hat{\omega}))$

Impulse response:  $h[n] = \delta[n] - 3\delta[n-1] + \delta[n-2]$

Difference equation:  $y[n] = x[n] - 3x[n-1] + x[n-2]$

(c) Frequency response:  $H(e^{j\hat{\omega}}) = 2e^{-j\hat{\omega}} + 2e^{-j3\hat{\omega}}$

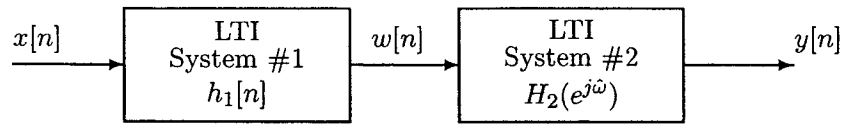
Impulse response:  $h[n] = 2\delta[n-1] + 2\delta[n-3]$

MATLAB Implementation:  $y = \text{conv}([0, 2, 0, 2], x)$



**PROBLEM Fall-04-Q.2.4:**

Consider the following cascade system:



where

$$h_1[n] = \delta[n] - 2\delta[n-1] + \delta[n-2] \quad \text{and} \quad H_2(e^{j\hat{\omega}}) = \frac{1}{2} + e^{-j\hat{\omega}}$$

- (a) Find and plot the impulse response  $h[n]$  of the overall system.

$$\begin{array}{r}
 \begin{array}{ccc}
 1 & -2 & 1 \\
 \frac{1}{2} & & \\
 \hline
 \frac{1}{2} & -1 & \frac{1}{2} \\
 & 1 & -2 & 1 \\
 \hline
 \frac{1}{2} & 0 & -\frac{3}{2} & 1
 \end{array} \\
 h[n] = \frac{1}{2}\delta[n] - \frac{3}{2}\delta[n-2] + \delta[n-3]
 \end{array}$$

- (b) Find the output signal  $y[n]$  if  $x[n] = \cos \pi n$ .

$$\begin{aligned}
 H(e^{j\hat{\omega}}) &= \frac{1}{2} - \frac{3}{2}e^{-j2\hat{\omega}} + e^{-j3\hat{\omega}} \\
 H(e^{j\pi}) &= \frac{1}{2} - \frac{3}{2}e^{-j2\pi} + e^{-j3\pi} \\
 &= \frac{1}{2} - \frac{3}{2} - 1 = -2
 \end{aligned}$$

$$\boxed{
 \begin{aligned}
 y[n] &= 2 \cos(\pi n - \pi) \\
 &\text{OR} \\
 y[n] &= 2 \cos(\pi n + \pi)
 \end{aligned}
 }$$