Signals and Systems – Spring 2024

Problem Set 8

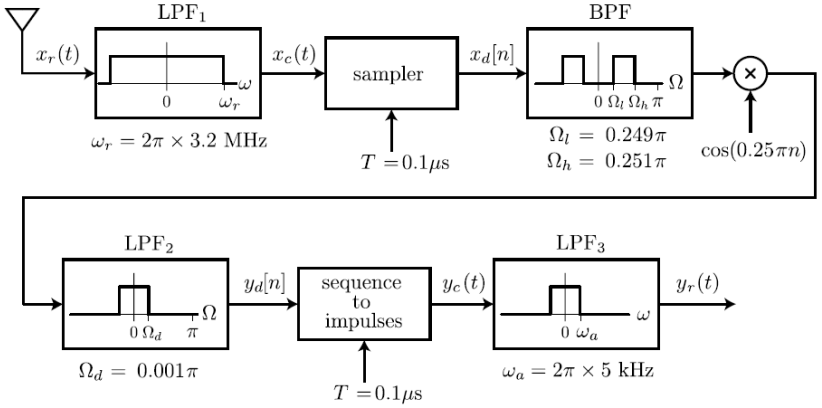
Issued: June 4th, 2024 Due: June 25th, 2024

Reading Assignment:

Chap. 8

Problem 1 :

Commercial AM radio stations broadcast radio frequencies within a limited range: $2\pi(f_c - 5 \text{ kHz}) < \omega < 2\pi(f_c + 5 \text{ kHz})$, where $f_c = \omega_c/(2\pi) = n \times 10$ kHz and n is an integer between 54 and 160. The system shown below is intended to decode one of the AM radio signals using DT signal processing methods. Assume that all of the filters are ideal.



sampler: $x_d[n] = x_c(nT)$

sequence to impulses: $y_c(t) = \sum_{n=-\infty}^{\infty} y_d[n]\delta(t - nT)$

Part a. Determine the center frequency f_c for the AM station that this receiver will detect.

Part b. Which of the following statement(s) is/are correct?

b1. Increasing the cutoff frequency ω_r of LPF_1 by a factor of 1.5 will cause aliasing.

b2. Decreasing the cutoff frequency ω_r of LPF_1 by a factor of 2 will have no effect on the output $y_r(t)$.

b3. Halving the sampling interval T would have no effect on the output $y_r(t)$.

b4. Doubling the sampling interval T would have no effect on the output $y_r(t)$.

Part c. Which of the following statement(s) is/are correct?

c1. Increasing the cutoff frequency Ω_d of LPF_2 will change $y_r(t)$ by adding signals from unwanted radio stations.

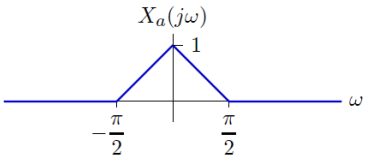
c2. Increasing the cutoff frequency Ω_d of LPF_2 will change $y_r(t)$ because aliasing will occur.

c3. Doubling the cutoff frequency Ω_d of LPF_2 will have no effect on $y_r(t)$.

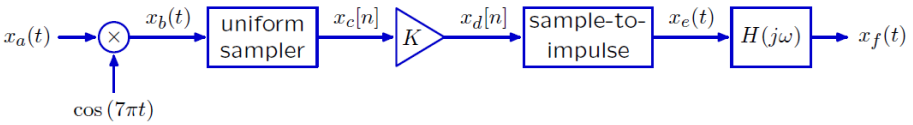
c4. Halving the cutoff frequency Ω_d of LPF_2 will have no effect on $y_r(t)$.

Problem 2 :

The Fourier transform of a signal $x_a(t)$ is given below.



This signal passes through the following system



where $x_c[n] = x_b(nT)$ and

$$x_e(t) = \sum_{n=-\infty}^{\infty} x_d[n]\delta(t - nT)$$

and

$$H(j\omega) = \begin{cases} T & \text{if } |\omega| < \frac{\pi}{T} \\ 0 & \text{otherwise.} \end{cases}$$

a. Sketch the Fourier transform of $x_f(t)$ for the case when $K = 1$ and $T = 1$.

Use your sketch to determine an expression for $X_f(j\omega)$ for the following intervals:

$0 < \omega < \pi/2$:

$\pi/2 < \omega < \pi$:

$\pi < \omega < 3\pi/2$:

$3\pi/2 < \omega < 2\pi$:

b. Is it possible to adjust T and K so that $x_f(t) = x_a(t)$?

If yes, specify a value T and the corresponding value of K (there may be multiple solutions, you need only specify one of them). If no, write **none.**

Problem 3 : OWN Problem 8.8

Problem 4 : OWN Problem 8.21

Problem 5 : OWN Problem 8.35

Problem 6 : OWN Problem 8.36