Reading in McClellan/Schafer/Yoder
3/28/16 — Section 4.2-4.3
3/30/16 — Section 4.3-4.4

Please read the homework notes given on the previous assignments.

Reflection Questions for PS7 (5 points)

(a) Compare your answers to the problems on PS6 to the solutions posted on the Blackboard site. Summarize what you learn from this comparison. What problems did you solve correctly? What problems did you solve incorrectly? Do you now understand how to solve the problems? Do you have questions about how the solutions were implemented?

(b) Write a one-paragraph summary of what you learned from the problems in this assignment. Your summary should include a brief description of the key concepts required to solve the problems. Comment on any problems you found difficult to solve and why they were difficult.

(c) What (if any) questions do you still have about the material covered on this problem set?

Note that you must solve the problems in the first edition of DSP First. If you do not have a copy of the first edition, one is on reserve at the library.

Problem 3.11 in McClellan/Schafer/Yoder

Problem 3.12 in McClellan/Schafer/Yoder

Problem PS7-1
This problem has three independent parts.

(a) Construct a linear chirp $x_a(t)$ such that the frequency decreases from 4000 Hz to 300 Hz in 5 seconds. Provide an equation for $x_a(t)$.

(b) Determine the instantaneous frequency (in Hz) of the following signal:

$$x_b(t) = \cos(-2\pi 600t^3 + 2\pi 600t^2 + 2\pi 600t) \quad 0 \leq t \leq 1$$

Provide a plot or sketch of the instantaneous frequency and answer the following questions. At what time $t$ is the instantaneous frequency the largest? How large is the largest frequency?

(c) Find the instantaneous frequency (in Hz) of the following signal

$$x_c(t) = 4 \cos(100 \sin(2\pi 4t) + 2\pi 600t)$$

Provide a plot or sketch of the instantaneous frequency and answer the following questions. How large is the largest frequency? How small is the smallest frequency?

See additional problems on the following pages.
Problem PS7-2  (Old ECE 201 exam problem)
An ocean scientist named Peter is planning an experiment. He will deploy 7 acoustic sources, each at a depth of 1000 m and suspended on a long cable. The 7 sources will be deployed in a circle with 100 km radius around a long (5km) vertical receiving array. Each source will transmit its own signal defined as $s_k(t)$, where $k$ is the source number:

$$s_k(t) = \cos(2\pi(\alpha t^2 + k\beta t)) \quad k = 1, 2, \ldots 7 \quad 0 \leq t \leq 10,$$

where $\alpha = 1.5$ and $\beta = 50$.

Two other scientists, Lora and Matt, are planning to work in the same part of the ocean. They plan to transmit signals from a source on an undersea glider. The glider can move around the environment. The signal $p(t)$ that Lora and Matt’s glider will transmit is defined as:

$$p(t) = (\cos(2\pi f_0 t) + 1) \cos(2\pi f_c t),$$

where $f_0 = 100$ Hz and $f_c = 240$ Hz. Lora and Matt are trying to convince Peter that their glider signal will not interfere with any of his source signals, thus they should be allowed to broadcast their signals at the same time as his sources are transmitting. In addition, Lora and Matt say that Peter’s sources will interfere with each other, so what’s the point in protecting the source signals from their glider?

Peter has asked you for your advice. What do you think? Will Lora and Matt’s glider transmissions interfere with any of Peter’s 7 sources? If so, which ones will it interfere with? Do Peter’s 7 sources interfere with each other?

Analyze the situation, and summarize your analysis below. Please include any calculations and/or plots that will help Peter, Lora, and Matt understand your results.

Problem PS7-3  (Old ECE 201 exam problem)
Which of the following signals can be sampled at a rate of $f_s = 100$ Hz without aliasing of any of the components?

(a) $x_a(t) = \cos(2\pi(20)t) + \cos(2\pi(25)t)$

(b) $x_b(t) = 1 + \cos(2\pi(100)t)$

(c) $x_c(t) = \cos(2\pi(40)t)\cos(2\pi(50)t)$

(d) $x_d(t) = \cos(2\pi(15)t)\cos(2\pi(30)t)$

(e) $x_e(t) = \cos(2\pi(40)t)$

Justify your answer using sketches of the signal spectra and indicate the criteria you used to determine which signals will not alias. Answers without justification will not receive credit.

Problem PS7-4  (Old ECE 201 exam problem)
Consider the signal $x(t) = 6 \cos(2\pi(40)t) + 4 \cos(2\pi(80)t)$.

(a) Sketch the spectrum of the signal $x(t)$. Show the spectrum as a function of $f$ in Hz.

For the rest of this problem, assume that the signal is sampled at a rate of $f_s = 100$ Hz.

(b) Sketch the spectrum for the sampled signal $x[n]$. Your spectrum should be shown as a function of the normalized frequency over the interval $-1 \leq \hat{f} \leq +1$.

(c) Write an equation for the sampled signal $x[n]$.

(d) Suppose that the signal is reconstructed from its samples using ideal reconstruction, i.e., it passes through an ideal D/C converter. Sketch the spectrum of the reconstructed signal $x_r(t)$ as a function of $f$ in Hz.

(e) Write an equation for the reconstructed signal $x_r(t)$. Is $x_r(t) = x(t)$? Why or why not?