THE UNIVERSITY OF TEXAS AT AUSTIN
Dept. of Electrical and Computer Engineering

EE313 Linear Systems and Signals

Problem Set #9: Fourier Transform Properties and Laplace Transform Definition

Date assigned: October 28, 2010
Date due: November 4, 2010

Reading: *Signals and Systems*, Sections 5.1–5.5, 6.1–6.3, 6.9 and 9.1–9.3

You may use any computer program to help you solve these problems, check answers, etc.

As stated on the course descriptor, "Discussion of homework questions is encouraged. Please be absolutely sure to submit your own independent homework solution."

The office hours in ENS 433B for Prof. Evans follow:

- Tuesdays 12:15pm–1:00pm (right after lecture)
- Wednesdays 12:30pm–2:00pm
- Thursdays 12:15pm–1:00pm (right after lecture)
- Fridays 9:30am–11:00am

On Friday, November 5th, Prof. Evans will not be available for his afternoon coffee hour. Prof. Evans can be reached at `bevans@ece.utexas.edu`.

The teaching assistant is Mr. Jackson Massey. His office hours will be on Wednesdays 4:00pm–7:00pm in ENS 138. Mr. Massey can be reached at `jackson.massey@gmail.com`.

The ECE Department is offering tutoring sessions for all basic sequence ECE courses, including EE 313, on Sundays through Thursdays, 7:00–10:00 pm, in ENS 314. Mr. Massey will be a tutor during the Monday and Wednesday evening sessions.

Problem 9.1 Sinusoidal Amplitude Modulation

This problem is a sequel to homework problem 7.1.

Here is the mathematical formula for a cosine waveform at fixed frequency ω_0:

$$x(t) = \cos(\omega_0 t)$$

Here is the Matlab code to play the note E in the Western Musical Scale at 660 Hz for two seconds using a sampling rate (Fs) of 8192 Hz.

```
Fs = 8192;
numberOfSeconds = 2;
n = 1 : numberOfSeconds*Fs;
f0 = 660;
w0 = 2*pi*f0/Fs;
noteSound = cos(w0*n);
sound(noteSound);
```

Write the Matlab code to implement sinusoidal amplitude modulation by multiplying the 660 Hz tone by a 220 Hz tone, i.e.

$$y(t) = \cos(2\pi 660t)\,\cos(2\pi 220t)$$

(a) Play the resulting signal $y(t)$ for $2s$ using the sound command.

Is the volume louder, softer, or the same vs. playing the E note?

(b) Submit a plot of the spectrum of the resulting signal $y(t)$.

(c) From the plot in (b), please answer the following questions:

How many significant frequencies are present?

What are their values?

How does this finding agree (or not) with what you heard when you played the resulting signal using the sound command in part (a)?

Write the Matlab code to implement sinusoidal amplitude modulation of $y(t)$:

$$v(t) = y(t)\,\cos(2\pi 140t)$$

(d) Play the resulting signal $v(t)$ for $2s$ using the sound command.

Is the volume louder, softer, or the same vs. playing $y(t)$?

(e) Submit a plot of the spectrum of the resulting signal $v(t)$.

(f) From the plot in (e), please answer the following questions:

How many significant frequencies are present?

What are their values?

How does this finding agree (or not) with what you heard when you played the resulting signal using the sound command in part (d)?

Problem 9.2 Sinusoidal Amplitude Demodulation

Roberts, Ch. 6, Problem 36.

What value should f_m be so that $y_f(t) = x_t(t)$?

Note: In this problem, $x_t(t)$ is the message signal to be transmitted, and $x_r(t)$ is the received signal. The frequency response of the linear time-invariant model of the communication channel is given by $H(f)$. In this problem, we will ignore the processing delays in the LTI model of the channel and the lowpass filter in the receiver.

Problem 9.3 Using the Forward Laplace Transform Definition

Roberts, Ch. 9, Problem 18, parts (a), (d) and (e).

Problem 9.4 Using Forward Laplace Transform Properties

Roberts, Ch. 9, Problem 21