EEL 4350 – Principles of Communication

Project 1

Due Thursday, January 29 at the Beginning of Class

Description

This project focuses on using MATLAB to perform energy and Fourier series computations. In addition, abilities to define functions and perform plotting operations are reviewed.

Deliverables

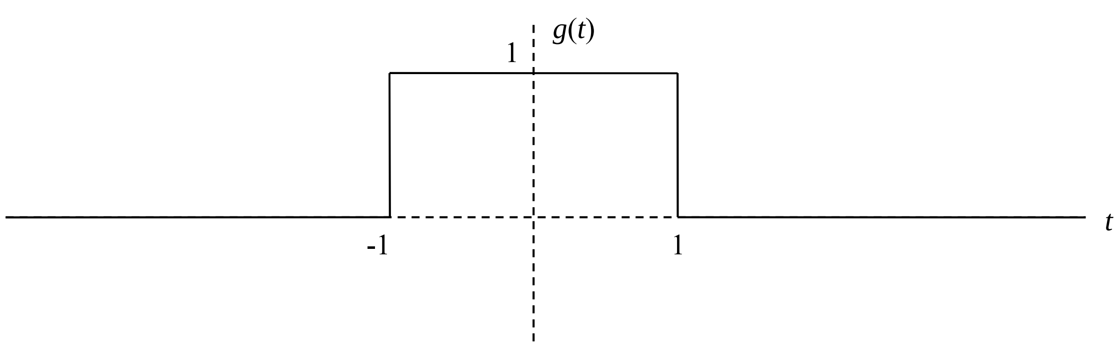
Your deliverable will be in the form of a hard-copy report with the following clearly labeled sections:

- Cover sheet including your name, the name and number of the course, and the project number (1).
- Brief Description of Project (1 to 2 paragraphs recommended)
- MATLAB (.m) script file. For this project you should create one .m file that performs all operations required. You should also place comments in the system that would be helpful to someone reading your program; i.e. at least state where each section of code begins. Use the % sign before placing comments in the .m file.
- Description of results and answers to questions organized as given below with plots included as numbered figures ("Figure 1", "Figure 2", etc.). The Figures should be placed at appropriate places within the body of your descriptions.
- Conclusions (likely a 1 paragraph summary)

Failure to adhere to this format will result in deduction of points.

Project Description and Assignment

Consider the single-pulse signal plotted as follows:



1. Signal Definition and Plotting

- Create MATLAB code to define this function g(t). Define the function in a separate MATLAB file (include this file in your report). The code for this file should be written as follows:

```
function g = projectnewfunction(t)
if t>-1
   if t<1
      g = t-t+1;
   else g = t-t;
   end
else g =t-t;
end
```

Make sure you use t in the calculations; for example, instead of writing 0, write t – t; this will avoid potential errors in calling this function. Plot the function from t = -5 to t = 5 (Figure 1). Make sure to label the x and y axes appropriately.

To plot the function, use the code

```
fplot(@project1newfunction,[-5 5],1601)
```

fplot is used to plot functions in MATLAB. The @ operator gives a handle (similar to an address) to the location in memory where the function is stored. The [-5 5] gives the range of the function variable (t in this case) over which the function is plotted. The third argument gives the number of data points to be used in the plot.

2. Calculation of Signal Energy

- Use MATLAB to calculate the energy of $g(t)$. Because the signal is only nonzero from -1 to 1, you are allowed to integrate from -1 to 1. Use the MATLAB function *quad* to perform this integration. Recall that typing "help quad" in the command window will allow you to learn how to use this function. The numerical integration of this signal can be performed with the following command:

```
Energy = quad(@functionsquare,-0.9999999,0.9999999, 1e-10)
```

To obtain this result, the function "functionsquare" should be defined in a separate M-file (call it "functionsquare.m") as follows:

```
function h = functionsquare(t);
%This function calculates the square of the function project1newfunction(t)
h = (abs(project1newfunction(t))).^2;
```

Does your program produce a correct result for the energy? Verify your result with hand calculations.

3. Fourier Series

Now consider the function

$$g(t) = \cos t + \cos 3t$$

- Calculate the exponential Fourier series magnitude coefficients D_n and phase coefficients θ_n of g(t) using the Fast Fourier Transform (fft). Section 2.10 and specifically the computer example shown in your text briefly how to use the fft for this purpose. Assign T0 as the fundamental period of the signal (in this case this is 2*pi). Use the function *stem* to plot the magnitude and angle versus frequency (Figure 2). (Note: The "Computer Example" in your textbook plots versus index k; to convert k to frequency *f*, use *f* = k/T0. There will be two plots: amplitude and phase; format the plot into a 2 x 1 subplot (Figure 2). In the plot, use the following code to get appropriate plot formatting:

```
figure
subplot(2,1,1), stem(f,Dnmag);
axis([0 5 -1 1]);
title('Magnitude Spectrum of g(t)');
xlabel('frequency (Hz)');
ylabel('Dn');
subplot(2,1,2), stem(f,Dnangle);
axis([0 5 -5 5]);
title('Phase Spectrum of g(t)');
xlabel('frequency (Hz)');
ylabel('<Thetan');
```

  The function 'axis' defines the x and y axis limits of the plot (type "help axis" in the MATLAB command window to learn more).

  What are the amplitudes of the nonzero coefficients (keep in mind this is an exponential Fourier series, not a trigonometric Fourier series). Do your results make sense?

- Let *h*(*t*) = 2*g*(*t*). Plot the exponential Fourier Series amplitude and phase coefficients for h(t) in a 2 x 1 subplot (Figure 3). What, if any, is the difference between the spectrum for h(t) and the spectrum for f(t)? Does this make sense? Discuss.
- Let *m*(*t*) = *g*(*t*/2); this expands the pulse in time by a factor of 2. Plot the exponential Fourier series amplitude and phase coefficients for *m*(*t*) in a 2 x 1 subplot (Figure 4). You will need to adjust your fundamental period T0 to half of that defined in the previous sections because the signal is expanding in time. What happens to the spectrum? Is this what you would expect?
- Let *n*(*t*) = *g*(*t*-2); this shifts the pulse *g*(*t*) to the right by 2. Plot the exponential Fourier series amplitude and phase coefficients for *n*(*t*) (Figure 5) in a 2 x 1 subplot. Make sure to return T0 to the value that was used for *g*(*t*) and *h*(*t*). In general, what changes can you observe in the magnitude and phase plots when comparing with the plots for *g*(*t*)?