

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
COLLEGE OF COMPUTER SCIENCES & ENGINEERING
COMPUTER ENGINEERING DEPARTMENT
COE-241 – Data and Computer Communication
Matlab Programming Assignment #1: Fourier Series Expansion,
Power Spectral Density, and Dynamic Range of Signals
Due Date Sat April 6th, 2013 – In Class.

Problem [100 points] The handout on Fourier Series Expansion (FSE) included an example of the triangular periodic signal whose FSE is given by

$$s(t) = \frac{A}{2} + \frac{-4A}{\pi^2} \sum_{n=1,3,5,\dots}^{\infty} \frac{1}{n^2} \cos(2\pi n f_0 t)$$

This signal is also used in Assignment 2 and also in one of the major exam problems. Assume this signal is passed into an ideal low pass signal whose cut-off frequency is equal to $X > 0$ Hz. Assume all signal components with frequencies less or equal to X Hz shall pass.

- It is desired to write a Matlab code that:
 1. Asks user to specify the variables: A , T , and X .
 2. The code analyzes the **filtered** signal, $s_o(t)$, and computes, in a table manner, the power at every frequency component.
 3. The code provides three plots: (a) a plot for the filtered signal, $s_o(t)$, (b) plot for the power spectral density function of the filtered signal $s_o(t)$, and (c) a plot for the power ratio (in dBs) curve versus the frequency axis in Hz.

Sample outputs are shown below. For the plots the students are to use proper axes labels and ranges.

- Use the code to show that as the LPF cut-off frequency X increases, the filtered signal $s_o(t)$ becomes closer and closer to the original signal $s(t)$.

The developed Matlab code should be *very organized and well documented*. Use variable names identical or very close to the mathematical variable used in this problem statement. The documentation should clearly specify the sections of the code that correspond to each part of this programming assignment.

Students are encouraged to cooperatively discuss the problem and the Matlab know-how, however, each student must write and submit his *own* code. The submitted codes will be inspected for similarities.

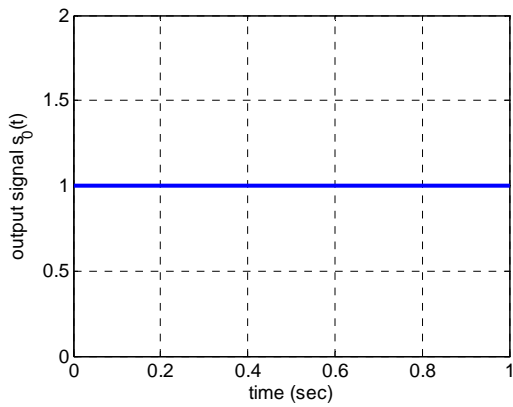
Generate the required outputs and import them into an organized Microsoft word file along with comments on the obtained results. Zip the word file together with the Matlab code and submit the zipped file by email to g200901970@kfupm.edu.sa and ashraf@kfupm.edu.sa. The name of the zip file should contain the following pattern: sXXXXXX_LastName_FirstName_ProgAssig1.zip. sXXXXXX is the student number. The email should include a proper subject line and a body text explaining its content.

To import figures into your word document, go to the Matlab figure Edit menu and select “copy figure”. Paste (special) the figure into the word file as “Picture (Enhanced Metafile)”. Please do not paste as any other format.

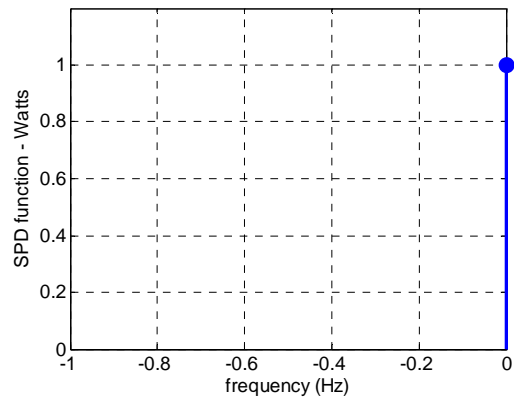
Students must ALSO submit a hardcopy of the programming assignment solution and the used Matlab code.

```
>> ProgAssign_1_TriangularFunction
Enter signal amplitude (volts)= 2
Enter signal period (seconds)= 0.5
Enter LPF cut-off frequency (Hz) = 1
Signal amplitude, A = 2.000 volts
Signal period, T = 0.500 sec - fundamental freq, f0 = 2.000 Hz
Filter cut-off, X = 1.000 Hz - Highest component, n = 0 (f = 0.000 Hz)
Total power = 1.000 Watts
Max power at f = 0.0 Hz - Power = 1.000 ( 0.000 dBW)
Dynamic range = -0.000 dB
```

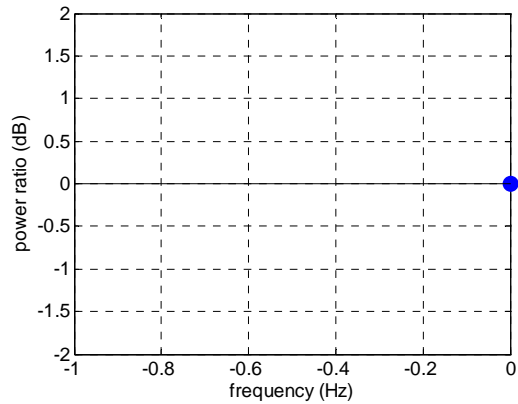
```
Power spectral density function and power ratio function:
Index : 0
freq (Hz) : 0.000
PSD (W) : 1.000
PSD-normalized : 1.000
PSD-normalized (dB): 0.00 >>
```



Plot for output signal $s_o(t)$.



Power spectral density function for $s_o(t)$.



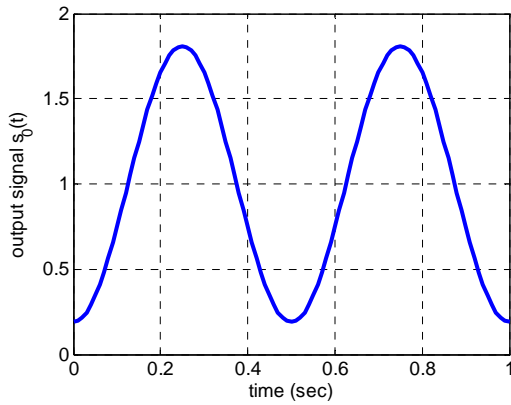
Power ratio (dB) curve vs frequency for $s_o(t)$.

Sample result # 1: extreme case where only DC component passes from the filter.

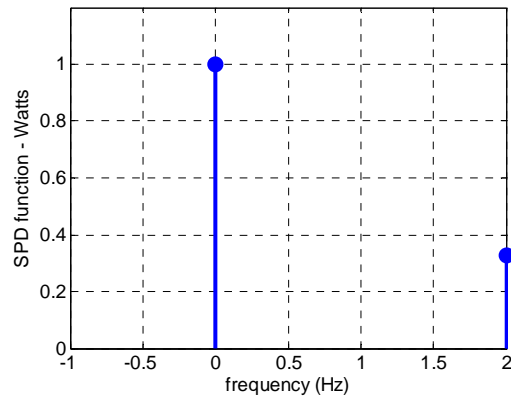
```
>> ProgAssign_1_TriangularFunction
Enter signal amplitude (volts)= 2
Enter signal period (seconds)= 0.5
Enter LPP cut-off frequency (Hz) = 2
Signal amplitude, A = 2.000 volts
Signal period, T = 0.500 sec - fundamental freq, f0 = 2.000 Hz
Filter cut-off, X = 2.000 Hz - Highest component, n = 1 (f = 2.000 Hz)
Total power = 1.329 Watts
Max power at f = 0.0 Hz - Power = 1.000 ( 0.000 dBW)
Dynamic range = 4.834 dB
```

Power spectral density function and power ratio function:

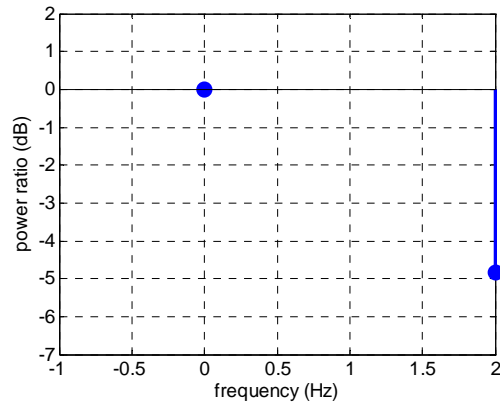
Index	:	0	1
freq (Hz)	:	0.000	2.000
PSD (W)	:	1.000	0.329
PSD-normalized	:	1.000	0.329
PSD-normalized (dB)	:	0.00	-4.83 >>



Plot for output signal $s_o(t)$.



Power spectral density function for $s_o(t)$.



Power ratio (dB) curve vs frequency for $s_o(t)$.

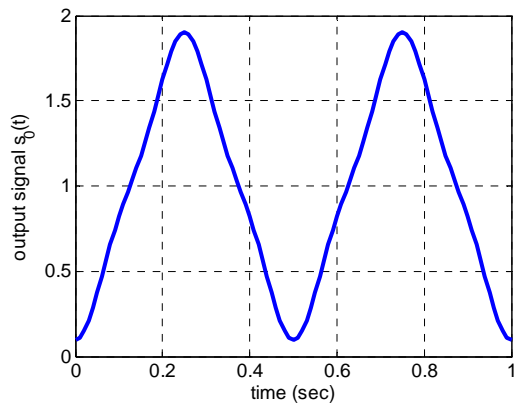
Sample result # 2: case of DC plus first harmonic (fundamental freq) – i.e. X = 2 Hz.

```
>> ProgAssign_1_TriangularFunction
Enter signal amplitude (volts)= 2
Enter signal period (seconds)= 0.5
Enter LPP cut-off frequency (Hz) = 9
Signal amplitude, A = 2.000 volts
Signal period, T = 0.500 sec - fundamental freq, f0 = 2.000 Hz
Filter cut-off, X = 9.000 Hz - Highest component, n = 3 (f = 6.000 Hz)
Total power = 1.333 Watts
Max power at f = 0.0 Hz - Power = 1.000 ( 0.000 dBW)
Dynamic range = 23.919 dB
```

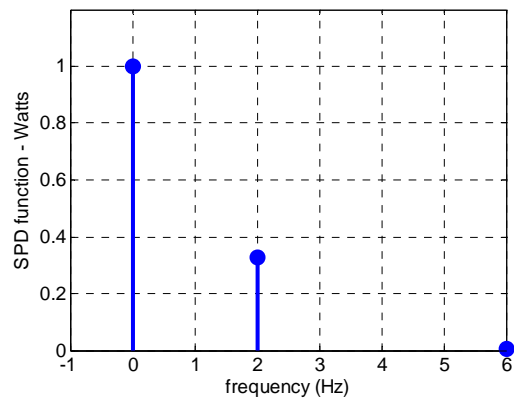
Power spectral density function and power ratio function:

Index	0	1	3
freq (Hz)	0.000	2.000	6.000
PSD (W)	1.000	0.329	0.004
PSD-normalized	1.000	0.329	0.004
PSD-normalized (dB)	0.00	-4.83	-23.92

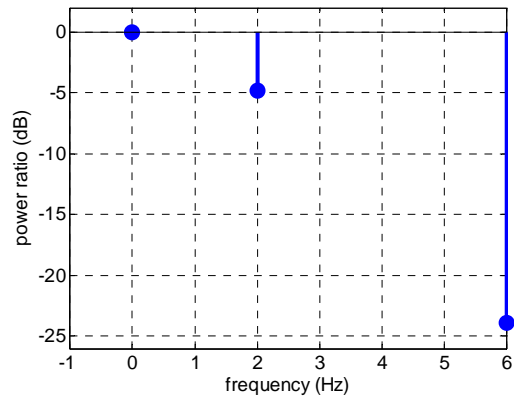
>>



Plot for output signal $s_o(t)$.



Power spectral density function for $s_o(t)$.



Power ratio (dB) curve vs frequency for $s_o(t)$.

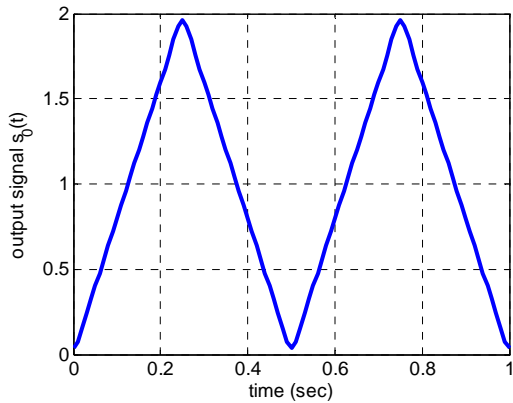
Sample result # 3: case of Assign 2 problem.

```
>> ProgAssign_1_TriangularFunction
Enter signal amplitude (volts)= 2
Enter signal period (seconds)= 0.5
Enter LPP cut-off frequency (Hz) = 20
Signal amplitude, A = 2.000 volts
Signal period, T = 0.500 sec - fundamental freq, f0 = 2.000 Hz
Filter cut-off, X = 20.000 Hz - Highest component, n = 9 (f = 18.000 Hz)
Total power = 1.333 Watts
Max power at f = 0.0 Hz - Power = 1.000 ( 0.000 dBW)
Dynamic range = 43.004 dB
```

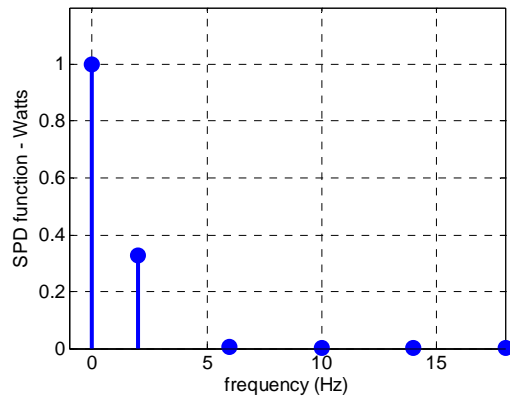
Power spectral density function and power ratio function:

Index	0	1	3	5	7	9
freq (Hz)	0.000	2.000	6.000	10.000	14.000	18.000
PSD (W)	1.000	0.329	0.004	0.001	0.000	0.000
PSD-normalized	1.000	0.329	0.004	0.001	0.000	0.000
PSD-normalized (dB)	0.00	-4.83	-23.92	-32.79	-38.64	-43.00

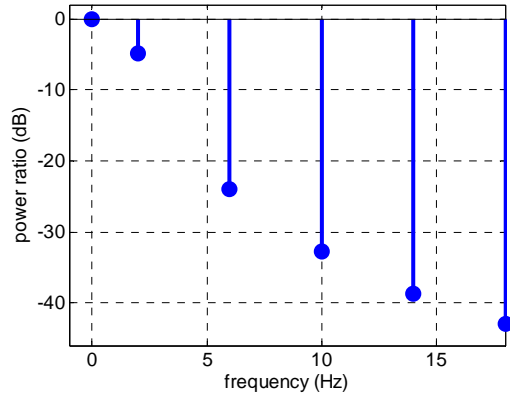
>>



Plot for output signal $s_o(t)$.



Power spectral density function for $s_o(t)$.



Power ratio (dB) curve vs frequency for $s_o(t)$.

Sample result # 4: case of X is large.