“FOURIER SERIES REPRESENTATION OF CONTINUOUS TIME SIGNALS

LAB # 10

CSE301L Signals & Systems Lab

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Registration No: **21PWCSE1993**

Class Section: **A**

“On my honor, as student of University of Engineering and Technology, I have neither given nor received unauthorized assistance on this academic work.”

Submitted to:

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CSE 301L: Signals & Systems Lab

LAB ASSESSMENT RUBRICS

Marking Criteria	Exceeds expectation (5-4)	Meets expectation (3-2)	Does not meet expectation (1)	Score
1. Realization of Experiment	Program compiles (no errors and no warnings). Program always works correctly and meets the specification(s). Completed between 71-100% of the requirements.	Program compiles (no errors and some warnings). Some details of the program specification are violated, program functions incorrectly for some inputs. Completed between 41-70% of the requirements.	Program fails to or compile with lots of warnings. Program only functions correctly in very limited cases or not at all. Completed less than 40% of the requirements.	30%
2. Ability to apply required code utility or data structure	Able to apply required data type or data structure and produce correct results. Familiarize and selects proper functions for simulation of given problem using software tools like MATLAB.	Able to apply required data type or data structure but does not produce correct results. Need guidance to select proper functions for simulation of given problem using software tools like MATLAB.	Unable to identify required data type or data structure. Incapable of selecting proper functions for simulation of given problem using software tools like MATLAB.	20%
3. Documentation	Clearly and effectively documented including descriptions of all variables/functions. Specific purpose is noted for each function, control structure, input requirements and output results.	Basic documentation including descriptions of all variables/functions. Specific purpose is noted for each function and control structure.	No documentation included.	10%
4. Ability to run/debug	Executes Matlab codes without errors, excellent user	Executes Matlab codes without errors. User prompts are	Does not execute Matlab codes due to errors.	20%

	prompts, good use of symbols, spacing in output. Thorough and organized testing has been completed and output from test cases is included.	understandable, minimum use of symbols or spacing in output. Some testing has been completed.	User prompts are misleading or nonexistent. No testing has been completed.	
5. Results compilation	Show processed results effectively by conducting simple computations and plotting using collected data	Show processed results effectively by conducting simple computations and plotting using collected data with minor error	Unable to show processed results effectively by conducting simple computations and plotting using collected data with minor error	10%
6. Efficiency	Excellent use of CPU and Memory.	Good but not smart use of CPU and Memory.	Inefficient use of CPU and Memory.	10%
7. Lab Performance (Team work and Lab etiquettes)	Actively engages and cooperates with other group members in an effective manner. Respectfully and carefully observes safety rules and procedures	Cooperates with other group members in a reasonable manner. Observes safety rules and procedures with minor deviation.	Distracts or discourages other group members from conducting the experiment. Disregards safety rules and procedures.	10%

Instructor:

Name: ___________________________ Signature: ________________________

Lab Objectives:

Objectives of this lab are as follows:

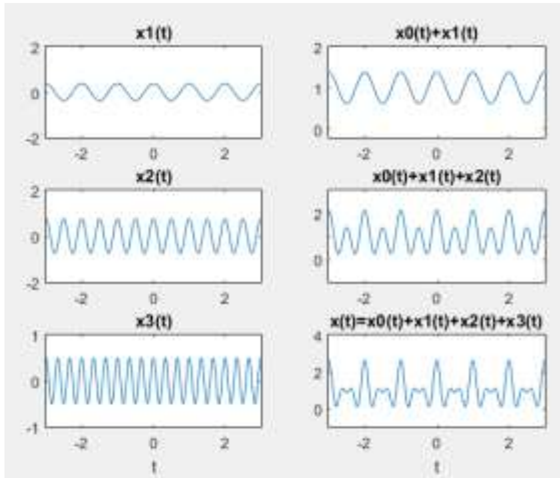
- Fourier Series Representation of Continuous Time Period Signals
- Convergence of CT Fourier Series

Task # 1:

Code:

```
t = -3:0.01:3; % duration of signal
% dc component for k=0
x0 = 1;
% first harmonic components for k=-1 and k=1
x1 = (1/4)*exp(j*(-1)*2*pi*t)+(1/8)*exp(j*(1)*2*pi*t);
y1 = x0 + x1; % sum of dc component and first harmonic
% second harmonic components for k=-2 and k=2
x2 = (1/2)*exp(j*(-2)*2*pi*t)+(1/4)*exp(j*(2)*2*pi*t);
y2 = y1 + x2; % sum of all components until second harmonic
% third harmonic components for k=-3 and k=3
x3 = (1/3)*exp(j*(-3)*2*pi*t)+(1/6)*exp(j*(3)*2*pi*t);
x = x0 + x1 + x2 + x3; % sum of all components until third harmonic
figure;
subplot(3,2,1);
plot(t,x1);
axis([-3 3 -2 2]);
title('x1(t)');
subplot(3,2,2);
plot(t,y1);
axis([-3 3 -0.2 2]);
title('x0(t)+x1(t)');
subplot(3,2,3);
plot(t,x2);
axis([-3 3 -2 2]);
title('x2(t)');
subplot(3,2,4);
plot(t,y2);
axis([-3 3 -1 3]);
title('x0(t)+x1(t)+x2(t)');
subplot(3,2,5);
plot(t,x3);
xlabel('t');
axis([-3 3 -1 1]);
title('x3(t)');
subplot(3,2,6);
plot(t,x);
xlabel('t');
axis([-3 3 -1 4]);
title('x(t)=x0(t)+x1(t)+x2(t)+x3(t)');
```

Output:



Task # 2:

A discrete-time periodic signal x[n] is real valued and has a fundamental period of N = 5. The non-zero Fourier series coefficients for x[n] are

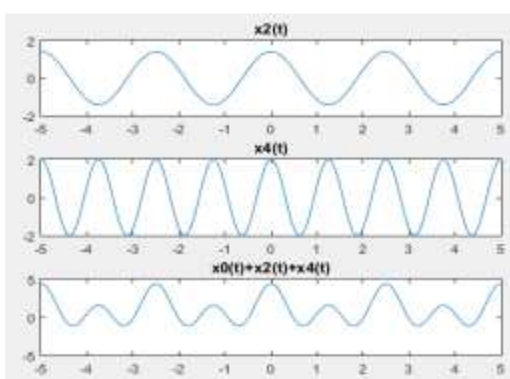
a0 =1 ,a2 = a-2 = ej pi/4, a4 = a-4 = 2ej pi/3

Express x[n] as a linear combination of given coefficients.

Code:

```
t = -5:0.01:5; % duration of signal
% dc component for k=0
x0 = 1;
% second harmonic components for k=?2 and k=2
x2 = (exp(j*(pi/4)))*exp(j*(-
2)*(2*pi/5)*t)+(exp(j*(pi/4)))*exp(j*(2)*(2*pi/5)*t);
y2 = x0 + x2; % sum of all components until second harmonic
% fourth harmonic components for k=?4 and k=4
x4 = (2*exp(j*(pi/3)))*exp(j*(-
4)*(2*pi/5)*t)+(2*exp(j*(pi/3)))*exp(j*(4)*(2*pi/5)*t);
x = x0 + x2 + x4; % sum of all components until fourth harmonic
figure;
subplot(3,1,1);
plot(t,x2);
title('x2(t)');
subplot(3,1,2);
plot(t,x4);
title('x4(t)');
subplot(3,1,3);
plot(t,x);
title('x0(t)+x2(t)+x4(t)');
```

Output:

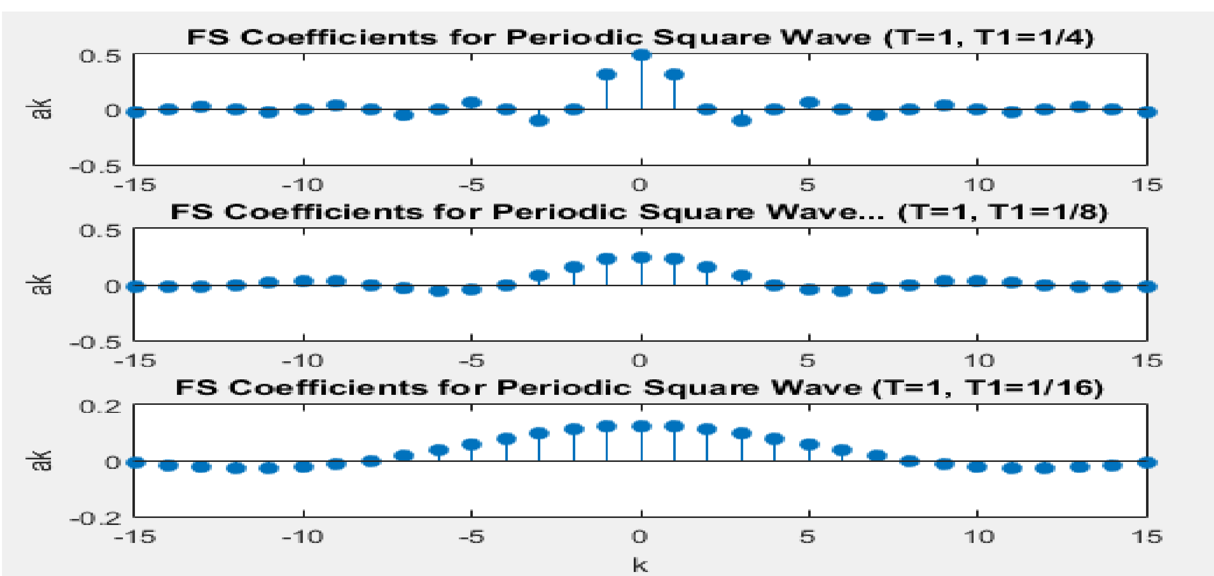


Task # 3:

Code:

```
k = -15:15; %number of square wave coefficients
T = 1; %time period of square wave
T1 = 1/4; %duty cycle of square wave
ak1 = sin(k*2*pi*(T1/T))./(k*pi); %square wave Fourier series
coefficients
% Ignore the "divide by zero" warning that happens
% because k in the denominator hits 0. We will now do
% a manual correction for a0 ?> ak1(16)
ak1(16) = 2*T1/T;
subplot(3,1,1);
stem(k,ak1,'filled');
ylabel('ak');
title('FS Coefficients for Periodic Square Wave (T=1, T1=1/4)');
T1 = 1/8;
ak2 = sin(k*2*pi*(T1/T))./(k*pi);
ak2(16) = 2*T1/T; % Manual correction for a0 ?> ak2(16)
subplot(3,1,2);
stem(k,ak2,'filled');
ylabel('ak');
title('FS Coefficients for Periodic Square Wave... (T=1, T1=1/8)');
T1 = 1/16;
ak3 = sin(k*2*pi*(T1/T))./(k*pi);
ak3(16) = 2*T1/T; % Manual correction for a0 ?> ak3(16)
subplot(3,1,3);
stem(k,ak3,'filled');
xlabel('k');
ylabel('ak');
title('FS Coefficients for Periodic Square Wave (T=1, T1=1/16)');
```

Output:



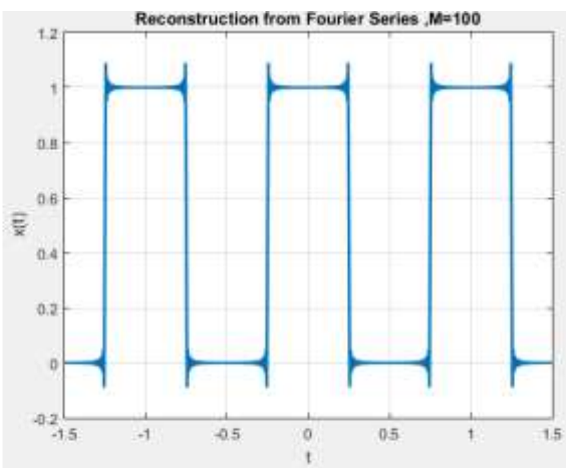
Task # 4:

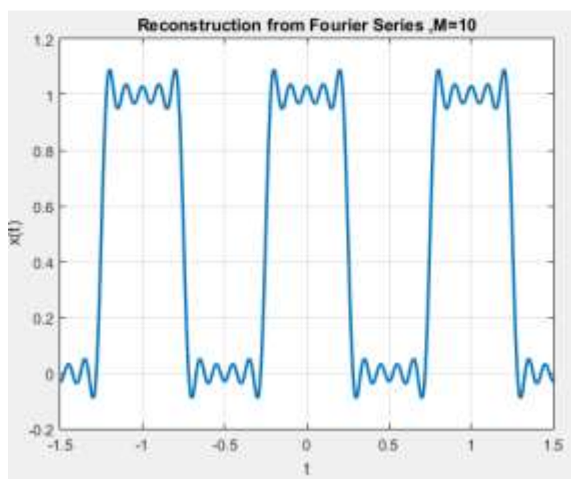
Considering the plots of square wave reconstructed using M = 10, 20, & 100 terms above, what do you observe about Gibb's phenomenon?

Code:

```
t = -1.5:0.005:1.5; %square wave duration
T = 1; %time period of square wave
T1 = 1/4; %duty cycle of square wave
w0 = 2*pi/T; %fundamental radian frequency of square wave
M = 100; %number of coefficients
k = -M:M; %2M+1 total coefficients to construct square wave
ak = sin(k*2*pi*(T1/T))./(k*pi);
ak(M+1) = 2*T1/T; % Manual correction for a0 ?> ak(M+1)
x = zeros(1,length(t));
for k = -M:M
x = x + ak(k+M+1)*exp(j*k*w0*t);
end
plot(t,x,'lineWidth',2);
grid;
xlabel('t');
ylabel('x(t)');
title('Reconstruction from Fourier Series');
```

Output:





Task # 5:

Given the following FS coefficients:

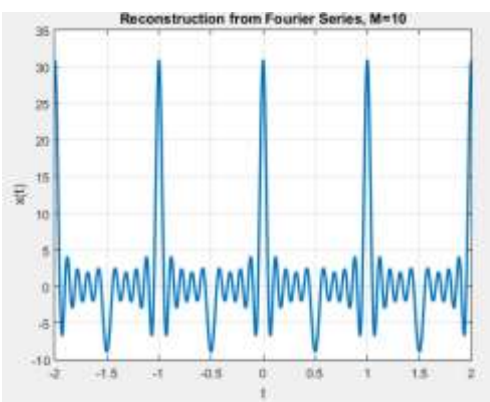
$$a_k = \begin{cases} 1, & k \ \ even \\ 2, & k \ \ odd \end{cases}$$

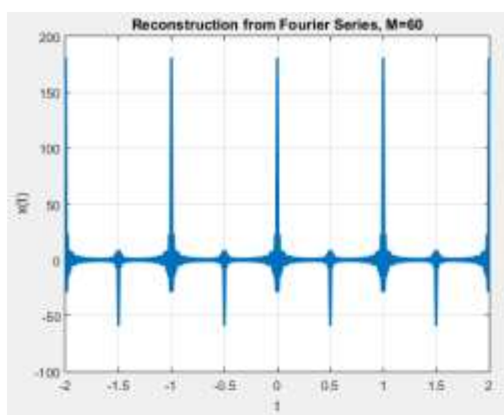
Plot the coefficients & reconstructed signal. Take the terms for reconstructed signal to be M = 10, 20, & 50. What effect do you see when M is varied?

Code:

```
t = -2:0.005:2; %square wave duration
T = 1; %time period of square wave
T1 = 1/4; %duty cycle of square wave
w0 = 2*pi/T; %fundamental radian frequency of square wave
M = 60; %number of coefficients
x = zeros(1,length(t));
for k = -M:M; %2M+1 total coefficients to construct square wave
if(mod(k,2)==0)
ak = 1;
x = x + ak*exp(j*k*w0*t);
else
ak = 2;
x = x + ak*exp(j*k*w0*t);
end
end
plot(t,x,'lineWidth',2);
grid;
xlabel('t');
ylabel('x(t)');
title('Reconstruction from Fourier Series, M=60');
```

Output:





Task # 6:

Given the following FS coefficients:

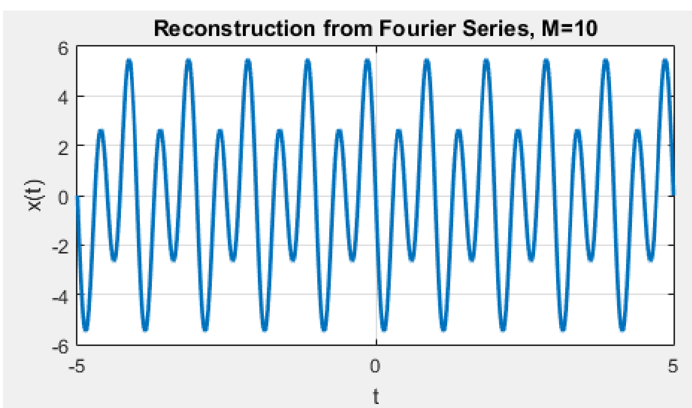
$$a_k = \begin{cases} jk, & |k| < 3 \\ 0, & otherwise \end{cases}$$

Plot the coefficients & reconstructed signal. Take 10 terms (M=10) for reconstructed signal.

Code:

```
t = -5:0.005:5; %square wave duration
T = 1; %time period of square wave
T1 = 1/4; %duty cycle of square wave
w0 = 2*pi/T; %fundamental radian frequency of square wave
M = 10; %number of coefficients
x = zeros(1,length(t));
for k = -M:M; %2M+1 total coefficients to construct square wave
if(abs(k)< 3)
ak = j*k;
x = x + ak*exp(j*k*w0*t);
else
ak = 0;
x = x + ak*exp(j*k*w0*t);
end
end
plot(t,x,'lineWidth',2);
grid;
xlabel('t');
ylabel('x(t)');
title('Reconstruction from Fourier Series, M=10');
```

Output:



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