KATHMANDU UNIVERSITY

DHULIKHEL, KAVRE

Subject: COMP-407: Digital Signal Processing

Lab no: 4

Submitted By:

Name: Ayush Kumar Shah
Roll no: 44
Group: CE 4^{th} year 1^{st} sem
Level: UNG

Submitted To:

Satyendra Nath Lohani Sir

Discuss Fourier Series and perform following operation.

Theory:

A Fourier series is an expansion of a periodic function f(x) in terms of an infinite sum of sines and cosines. Fourier series make use of the orthogonality relationships of the sine and cosine functions. The computation and study of Fourier series is known as harmonic analysis and is extremely useful to break up an arbitrary periodic function into a set of harmonics.

1. **Classical Fourier Series representation**

Synthesis equation:

$$x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\omega_0 t}$$

Analysis equation:

$$a_k = \frac{1}{T}\int_0^T x(t)e^{-jk\omega_0} dt$$

2. **Generalized equation:**

   i.

Synthesis equation:

$$x(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos(n\,\omega_0 t) + b_n \sin(n\omega_0 t)$$

P=T

Analysis equation:

$$a_0 = \frac{1}{T}\int_T x(t)dt$$

$$a_n = \frac{2}{T}\int_T x(t)\cos(n\omega_0 t)\,dt$$

$$b_n = \frac{2}{T}\int_T x(t)\sin(n\omega_0 t)\,dt$$

ii.

Synthesis equation:

$$f(x) = a_0 + \sum_{n=1}^{N} a_n \cos(\frac{n\pi x}{L}) + b_n \sin(\frac{n\pi x}{L})$$

P=2L

Analysis equation:

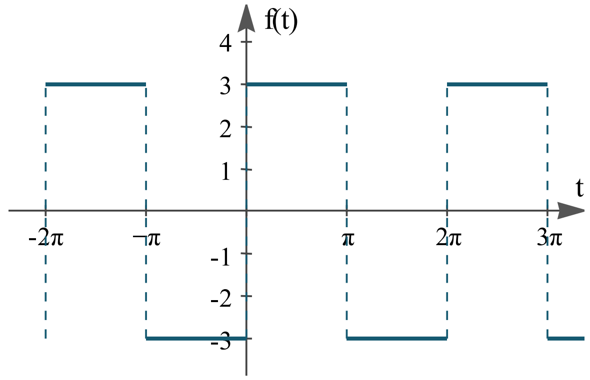
$$a_0 = \frac{1}{P}\int_P f(x)dt$$

$$a_n = \frac{2}{P}\int_P f(x)\cos\left(\frac{n\pi x}{L}\right)dx$$

$$b_n = \frac{2}{P}\int_P f(x)\sin\left(\frac{n\pi x}{L}\right)dx$$

1. **Fourier series expansion of odd signal for different N.(N= 3, 9, 100).**

We take an odd signal given by

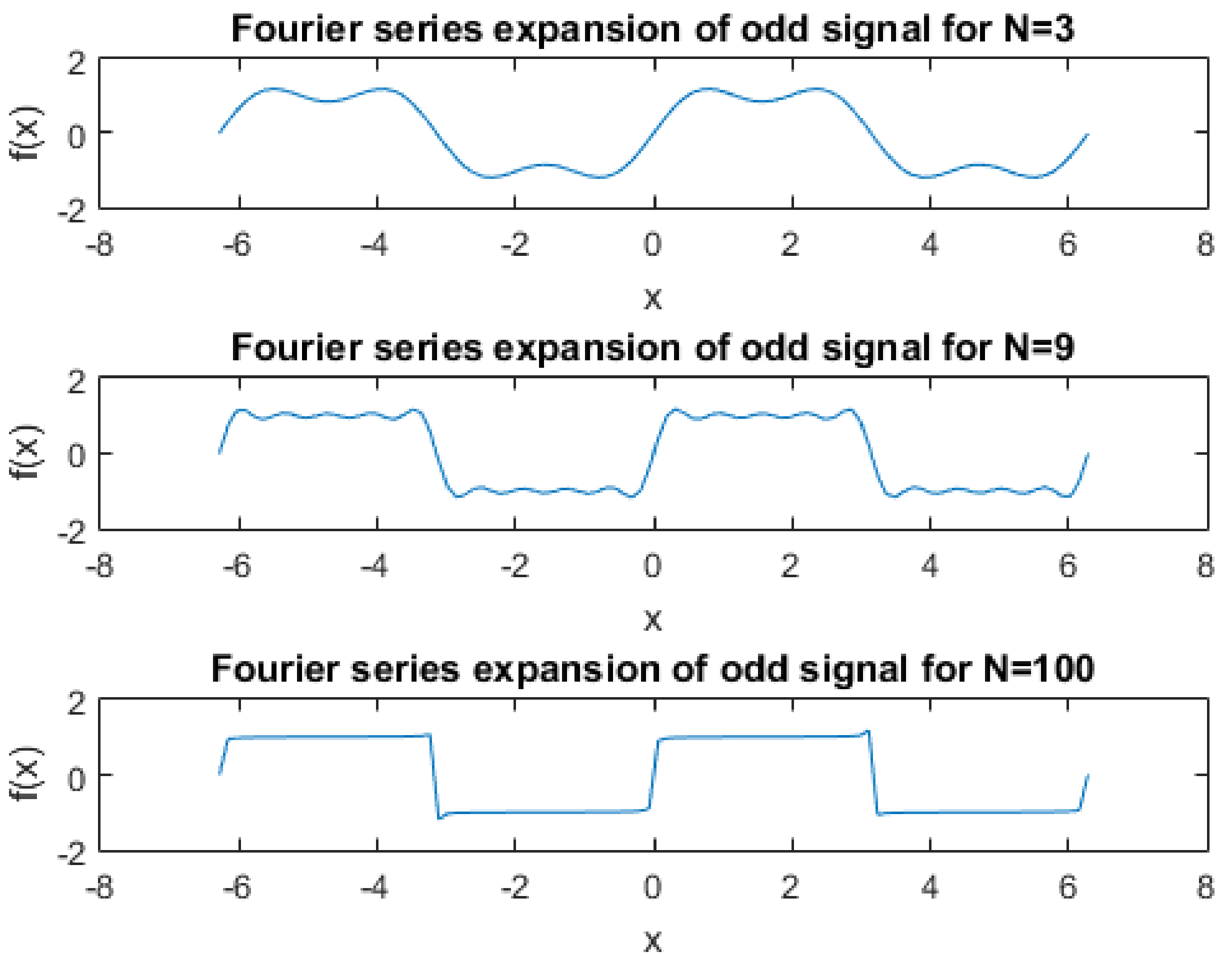


Code:

```
%odd signal
x = linspace(-2*pi,2*pi); % time grid
N1=3;
N2=9;
N3=100;
n1 = [1:2:N1];
n2 = [1:2:N2];
n3 = [1:2:N3];
a0=0;
c=1;
 % plot
figure;
```

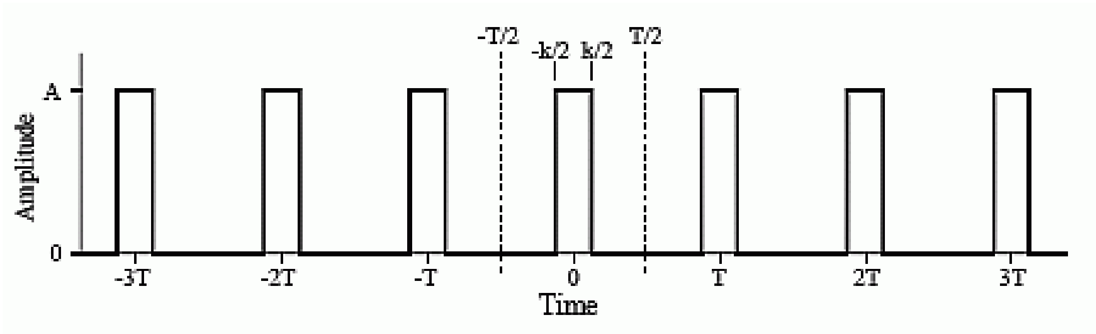
```
subplot(3,1,1);

fx =a0+ sum(4*c/pi*diag(1./n1)*sin(n1(:)*x(:)')); % summation
plot(x,fx);
xlabel('x');
ylabel('f(x)');
title('Fourier series expansion of odd signal for N=3');

subplot(3,1,2);
fx =a0+ sum(4*c/pi*diag(1./n2)*sin(n2(:)*x(:)')); % summation
plot(x,fx);
xlabel('x');
ylabel('f(x)');
title('Fourier series expansion of odd signal for N=9');

subplot(3,1,3);
fx =a0+ sum(4*c/pi*diag(1./n3)*sin(n3(:)*x(:)')); % summation
plot(x,fx);
xlabel('x');
ylabel('f(x)');
title('Fourier series expansion of odd signal for N=100');
```

Output:



2. **Fourier series expansion of even signal for different N. (N=3,9,100).**

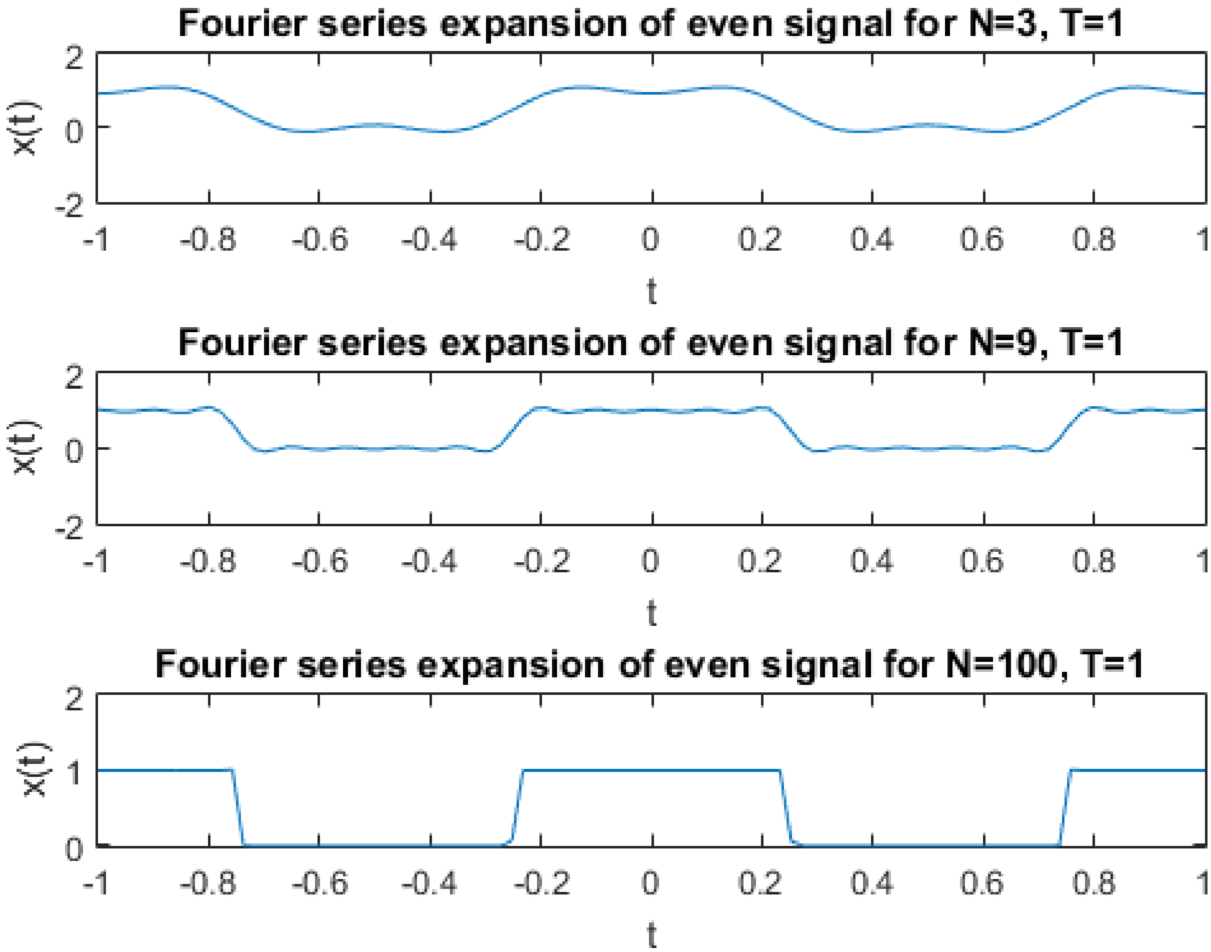
We take an even signal given by



Code:

```
%even signal
t = linspace(-1,1); % time grid
a0=1/2;
T=1;

% plot
figure;
subplot(3,1,1);
xt =a0+ sum(2/pi*diag((1./n1).*((-1).^((ceil(n1./2))+1)))*cos(2*pi*(1/T)*n1(:)*t(:)')); % summation
plot(t,xt);
xlabel('t');
ylabel('x(t)');
title('Fourier series expansion of even signal for N=3, T=1');

subplot(3,1,2);
xt =a0+ sum(2/pi*diag((1./n2).*((-1).^((ceil(n2./2))+1)))*cos(2*pi*(1/T)*n2(:)*t(:)')); % summation
plot(t,xt);
xlabel('t');
ylabel('x(t)');
title('Fourier series expansion of even signal for N=9, T=1');

subplot(3,1,3);
xt =a0+ sum(2/pi*diag((1./n3).*((-1).^((ceil(n3./2))+1)))*cos(2*pi*(1/T)*n3(:)*t(:)')); % summation
plot(t,xt);
xlabel('t');
ylabel('x(t)');
title('Fourier series expansion of even signal for N=100, T=1');
```

Output:



Conclusion:

Thus, we discussed Fourier series representation of periodic signals and represented odd and even periodic series as Fourier series with different values of N.