Xi'an Jiaotong-Liverpool University

西交利物浦大学

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE412 Advanced Signal Processing

Assignment I: Signals and Spectra with Matlab

Student Name Zhiyu.Xu

Student ID 1926905

Email Address Zhiyu,Xu19@student.xjtlu.edu.cn

September 2019

Contents

Problem 1

1.1 (a)

1.1.1 Result and code

Result

The real part	The imaginary part	The absolute value	The angle
1	1	1.4142	0.7854

```
%Problem1a
clear
clc
x=1+1j;
a1=real(x);
a2=imag(x);
a3=abs(x);
a4=angle(x);
```

Code 1

1.2 (b)

1.2.1 Image result and code

Result

Parts / Numbers	The real part	The imaginary part	The absolute value	The angle
1	1	0	1	0
j	0	1	1	1.5708
-1	-1	0	1	3.1416
-j	0	-1	1	-1.5708

```
%Problem1b
clear
clc
x=[1,1j,-1,-1j];
b1=real(x);
b2=imag(x);
b3=abs(x);
b4=angle(x);
```

Code 2

1.3 Discussion

Using the functions(like “real”, “imag” etc.) that come from matlab can get the answer to the question quickly.

Problem 2

2.1 (a)

2.1.1 Result and code

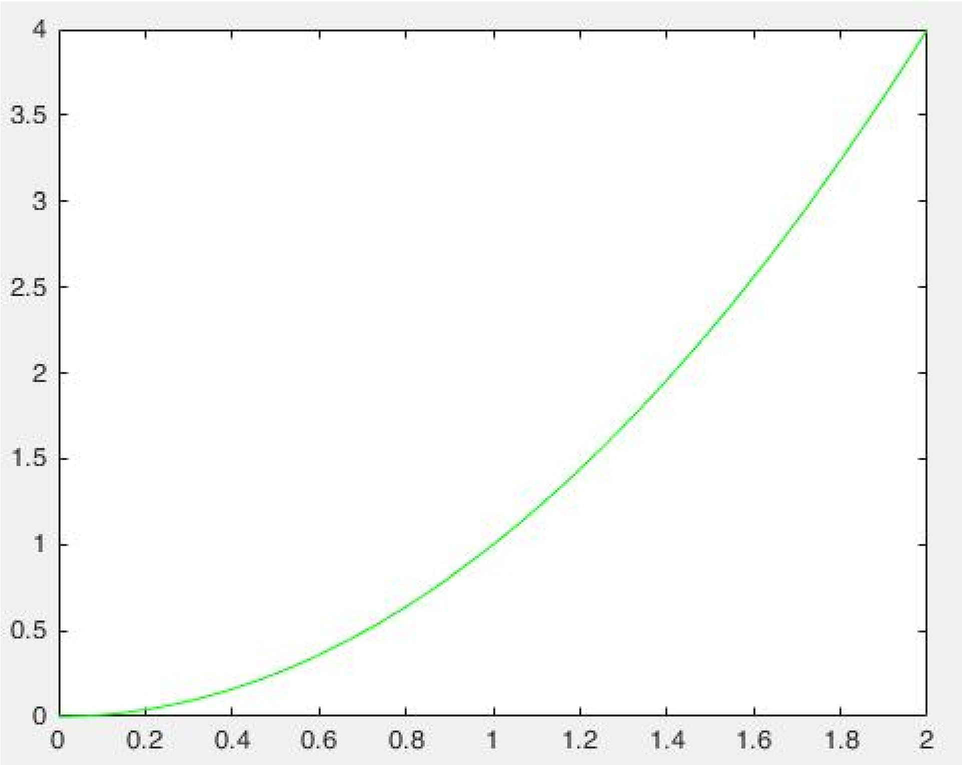

Figure 1 y=x^2

```
%Problem2a
clear
clc
dt = 0.01;
et = 2;
x = 0:dt:et;
y = x.^2;
plot(x,y,'g');
```

Code 3

2.2 (b)

2.2.1 Result and code

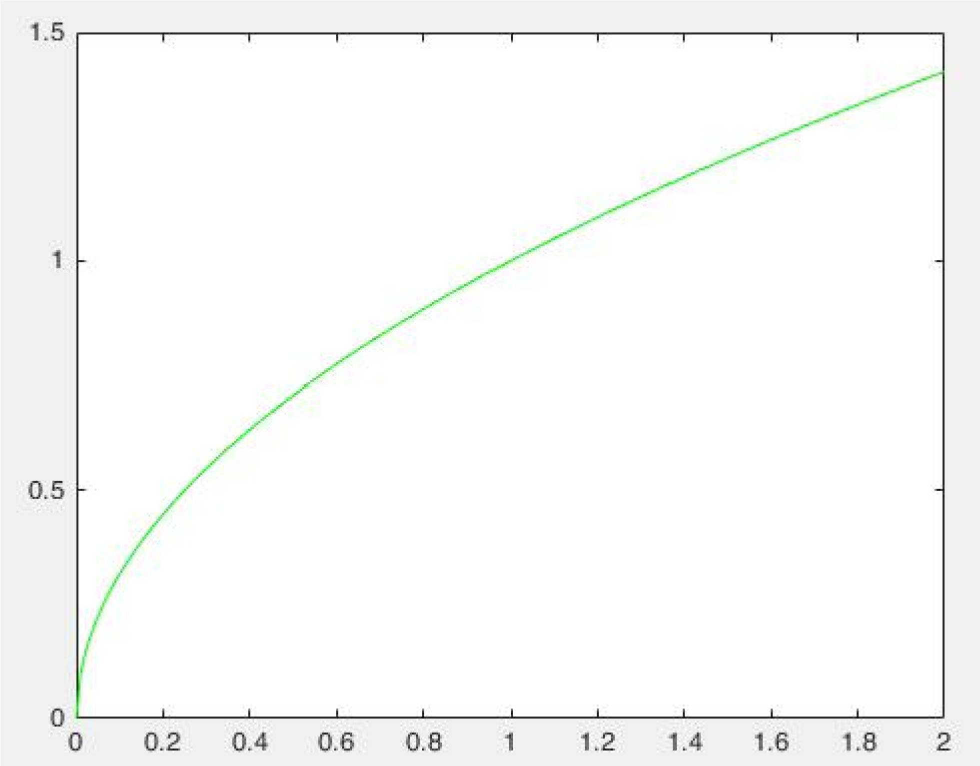

Figure 2 y=x/2

```
%Problem2b
clear
clc
dt = 0.01;
et = 2;
x = 0:dt:et;
y = x.^0.5;
plot(x,y,'g');
```

Code 4

2.3 (c)

2.3.1 Result and code

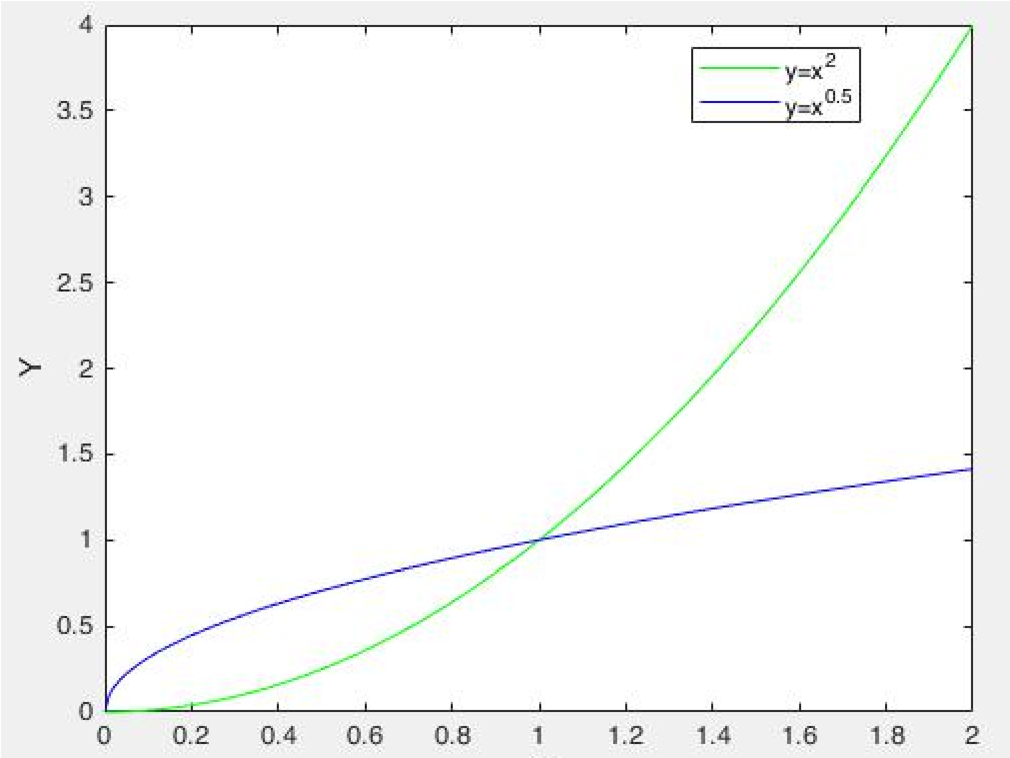

Figure 3 y=x^2 and y=x/2

```
%Problem2c
clear
clc
dt = 0.01;
et = 2;
x1 = 0:dt:et;
x2 = 0:dt:et;
y1 = x1.^2;
y2 = x2.^0.5;
h1=plot(x1,y1,'g');
hold on;
h2=plot(x2,y2,'b');
legend([h1,h2],'y=x^2','y=x^{0.5}');
xlabel('X');
ylabel('Y');
```

Code 5

Problem 3

3.1 (a)

3.1.1 Result and code

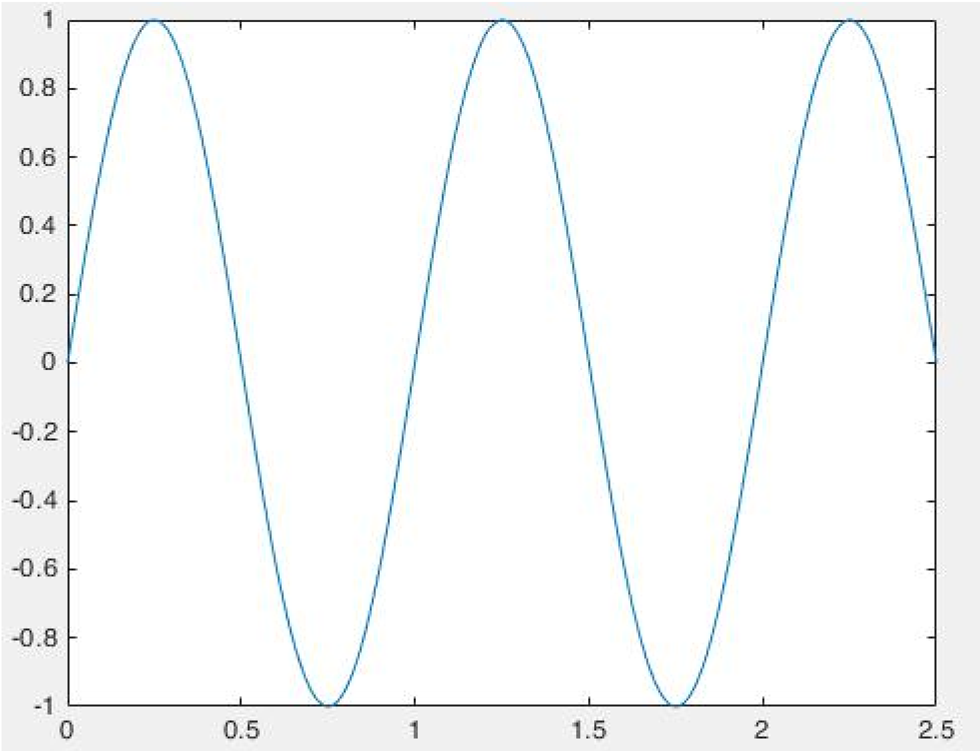

Figure 4 y=sin(2 π t)

```
%Problem3a
clear
clc
dt = 0.01;
et = 2.5;
t = 0:dt:et;
y = sin(2*pi*t);
plot(t,y);
```

Code 6

3.2（b）

3.2.1 Result and code

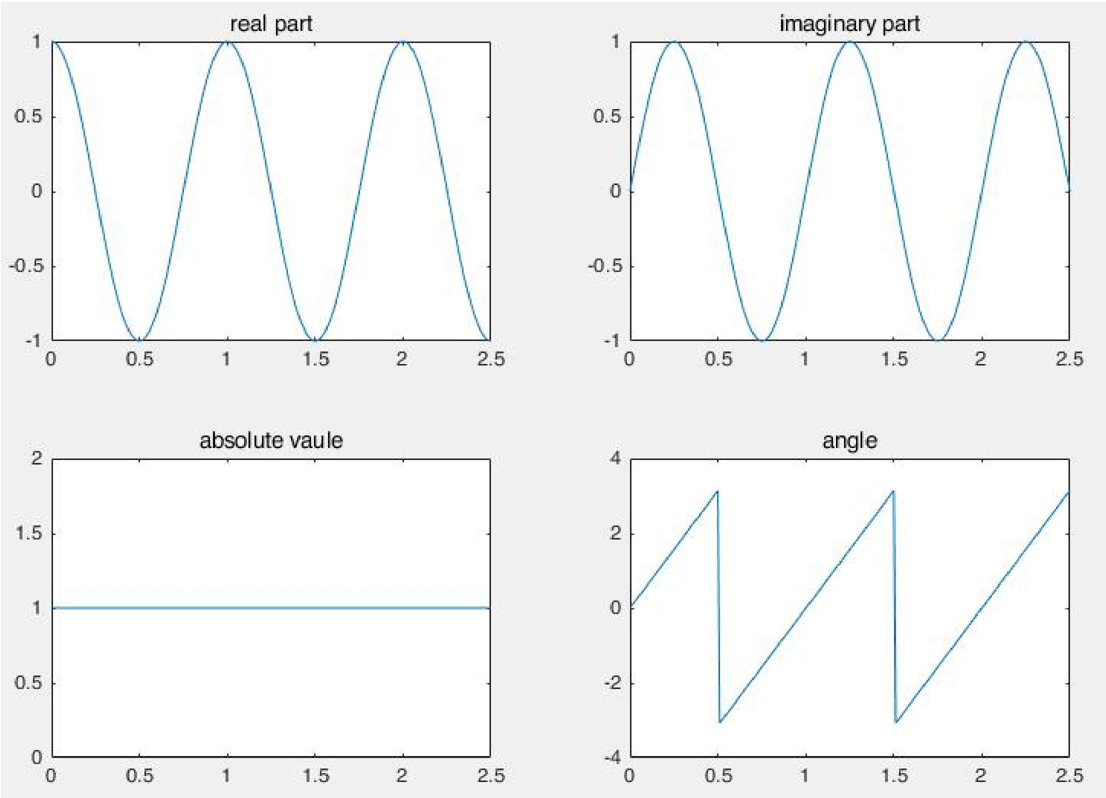

Figure 5 x=e^(j2 π t)

```
%Problem3b
clear
clc
dt = 0.01;
et = 2.5;
t = 0:dt:et;
x = exp(1j*2*pi*t);
real_x=real(x);
imag_x=imag(x);
abs_x=abs(x);
angle_x=angle(x);
figure;
subplot(2,2,1);
plot(t,real_x);title('real part');
subplot(2,2,2);
plot(t,imag_x);title('imaginary part');
subplot(2,2,3);
plot(t,abs_x);title('absolute vaule');
axis([0 et 0 2]);
subplot(2,2,4);
plot(t,angle_x);title('angle');
```

Code 7

3.3 (c)

3.3.1 Report and code

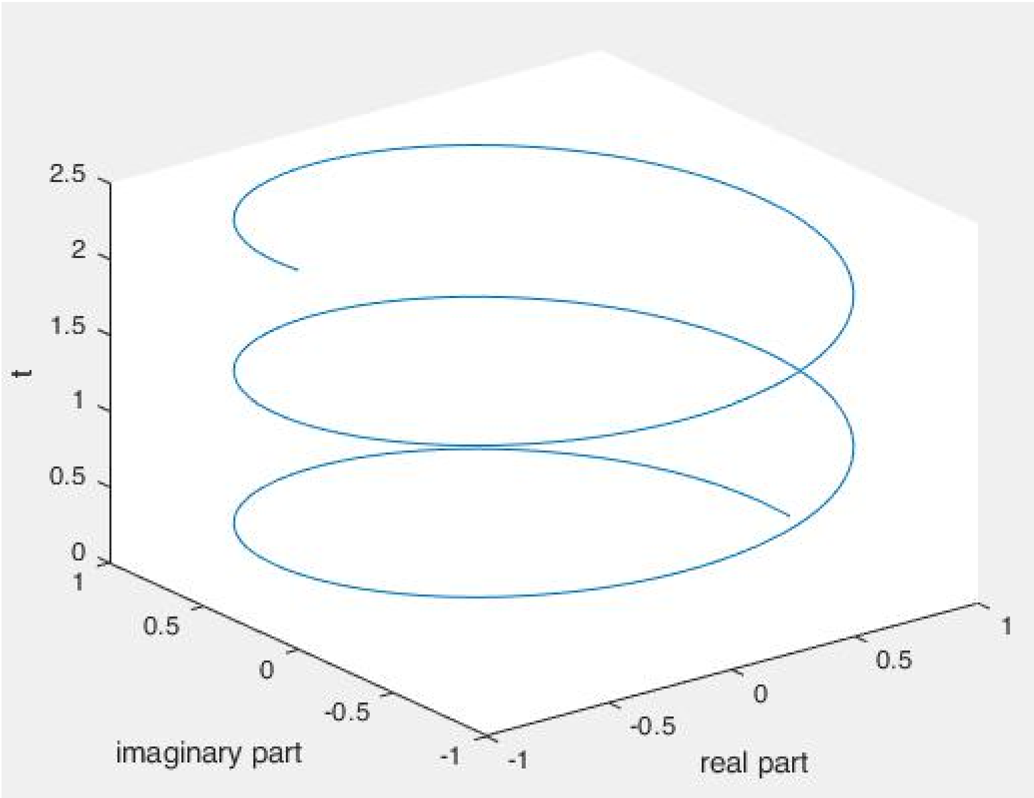

Figure 6 3D Image

```
%Problem3c
clear
clc
dt = 0.01;
et = 2.5;
t = 0:dt:et;
x = exp(1j*2*pi*t);
y = real(x);
z = imag(x);
plot3(y,z,t);
xlabel('real part');
ylabel('imaginary part');
zlabel('t');
```

Code 8

Problem 4

4.1 Result

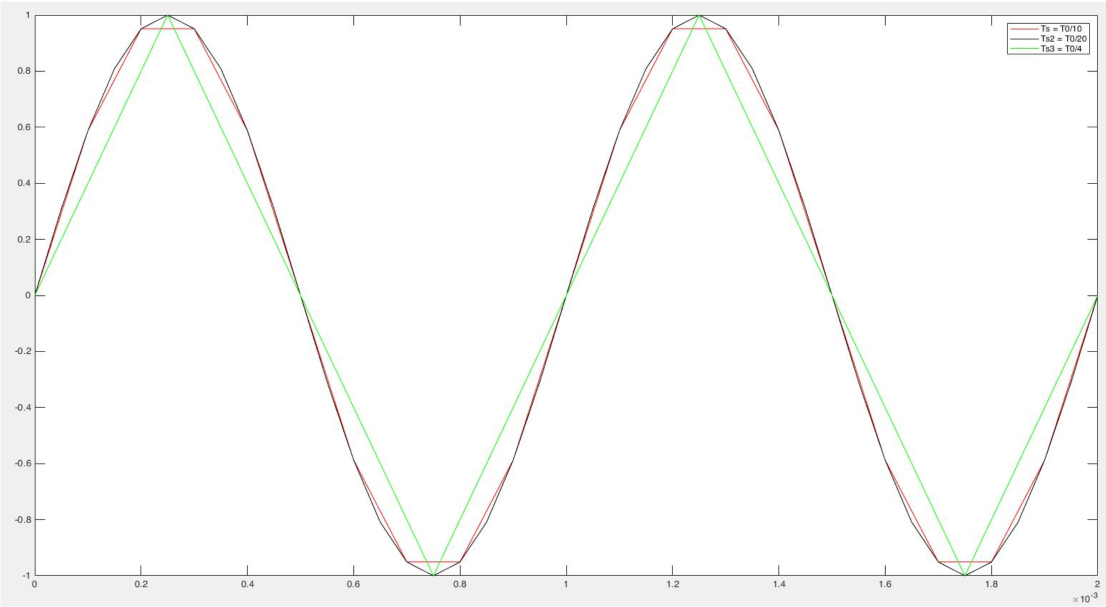

Figure 7 Result

4.2 Code

```
%Problem4
clear
clc
f0=10^3;
T0=1/f0;
et = 2*T0;
%% (a)
Ts = T0/10;
t = 0:Ts:et;
y = sin(2*pi*f0*t);
h1 = plot(t,y,'r');
hold on;
%% (b)
Ts2 = T0/20;
t2 = 0:Ts2:et;
y2 = sin(2*pi*f0*t2);
h2 = plot(t2,y2,'k');
hold on;
%% (c)
Ts3 = T0/4;
t3 = 0:Ts3:et;
y3 = sin(2*pi*f0*t3);
h3 = plot(t3,y3,'g');
legend([h1,h2,h3],'Ts = T0/10','Ts2 = T0/20','Ts3 = T0/4');
```

Code 9

4.3 Explanation of results

From Figure 7, we can observe three images similar to sin(x). Compared with the other two lines, the black one is the Smoothest, the red one is the second, and the greed one is almost a broken line. This is because the three sampling lines use different sampling frequencies. For example, the red one's sampling frequency is the highest, so sampling most points per unit time, make the image look smoothest.

Problem 5

5.1 Function of rect(t)

```
function [value] = rect(t)
%UNTITLED7 Summary of this function goes here
%   Detailed explanation goes here
if abs(t)<=0.5
    value=1;
else
    value=0;
end
```

Code 10

5.2 Result

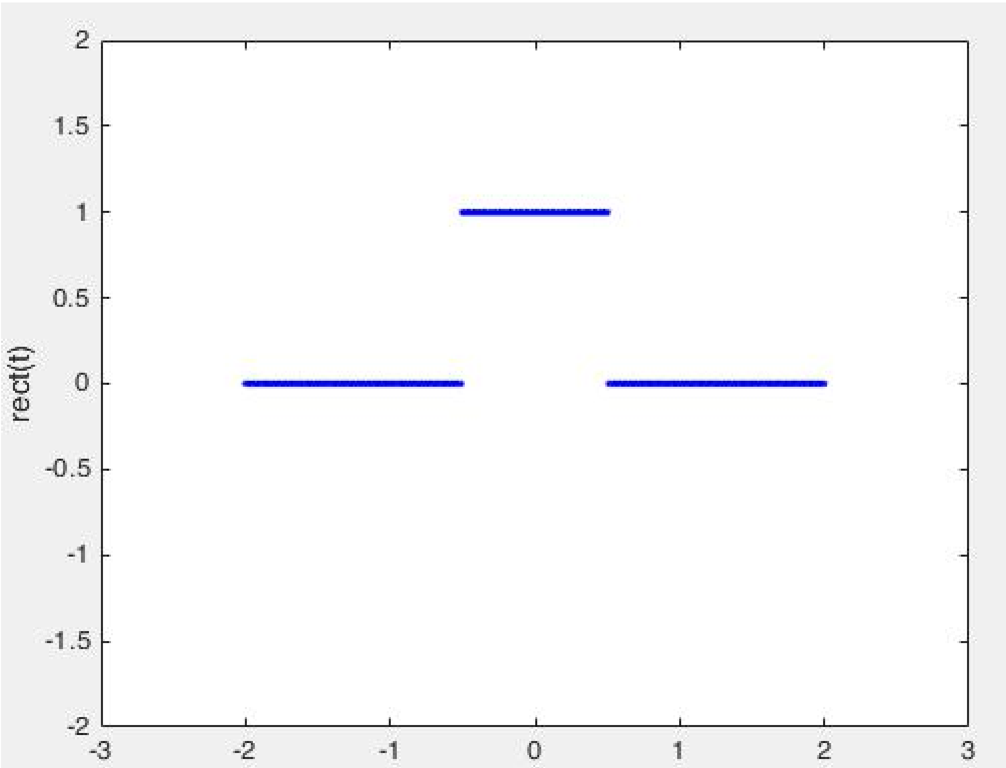

Figure 8 Result

5.3 Code

```
%Problem5
clear
clc
% (b)
dt = 0.01;
st = -2;
et = 2;
t = st:dt:et;
for t=st:dt:et
plot(t,rect(t),'.b');
hold on;
end
axis([-3 3 -2 2])
xlabel('t');
ylabel('rect(t)');
```

Code 11

Problem 6

6.1 Result

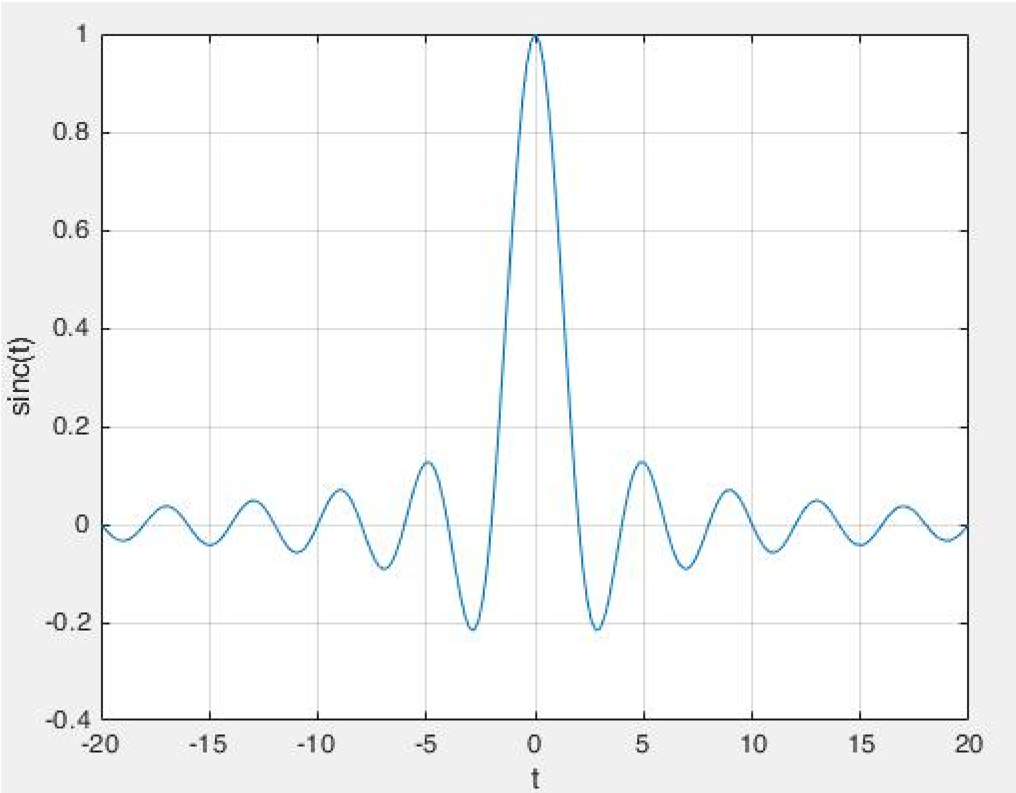

Figure 9 Result

6.2 Code

```
%Problem6
clear
clc
T0 = 2;
f0 = 1/T0;
Ts = T0/10;
st = -10*T0;
et = 10*T0;
t = st:Ts:et;
plot(t,sinc(f0*t))
grid on;
xlabel('t');
ylabel('sinc(t)');
```

Code 12

6.3 Explanation of zeros of s(t)

The function zero is the value of the corresponding independent variable x when f(x)=0. It can be seen from Figure 9 that the image has 20 intersections with the x-axis. Also this is 20 zeros.

Problem 7

7.1 Result

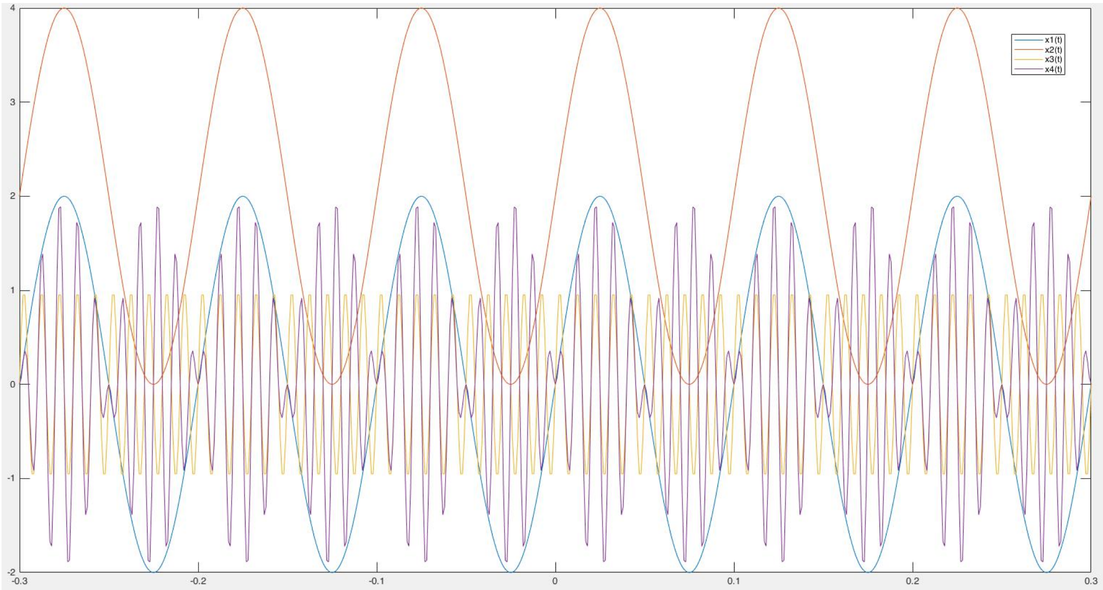

Figure 10 Result

7.2 Code

```
%Problem7
clear
clc
st = -0.3;
et = 0.3;
dt = 0.001;
%% (a)
f1 = 10;
t = st:dt:et;
x1=2*sin(2*pi*f1*t);
h1 = plot(t,x1);
hold on;
%% (b)
h2 = plot(t,2+x1);
hold on;
%% (c)
f3 = 10*f1;
x3 = sin(2*pi*f3*t);
h3 = plot(t,x3);
hold on;
%% (d)
x4 = x1.*x3;
h4 = plot(t,x4);
legend([h1,h2,h3,h4],'x1(t)','x2(t)','x3(t)','x4(t)')
```

Code 13

7.3 Conclusion analysis

As can be seen from Figure 10, there are four curves here. Curve X1(t) is Standard sinusoidal image of which amplitude and frequency are 2 and 10Hz ,respectively. Curve X2(t) is based on Curve X1(t) and translates 2 units upwards. Curve X3(t) is based on Curve X1(t) too, but the difference is that X3(t) only increase the frequency from 10Hz to 100Hz. Because of the X4(t) equal X1(t) times X3(t), the Curve X4(t) should also be the product of Curve X1(t) and X3(t). Therefore, the frequency of X4(t) is equal the X3(t)'s, and the envelope of X4(t) should follow the Curve X1(1) .

Problem 8

8.1 (a)(b)(c)(d)

8.1.1 Result

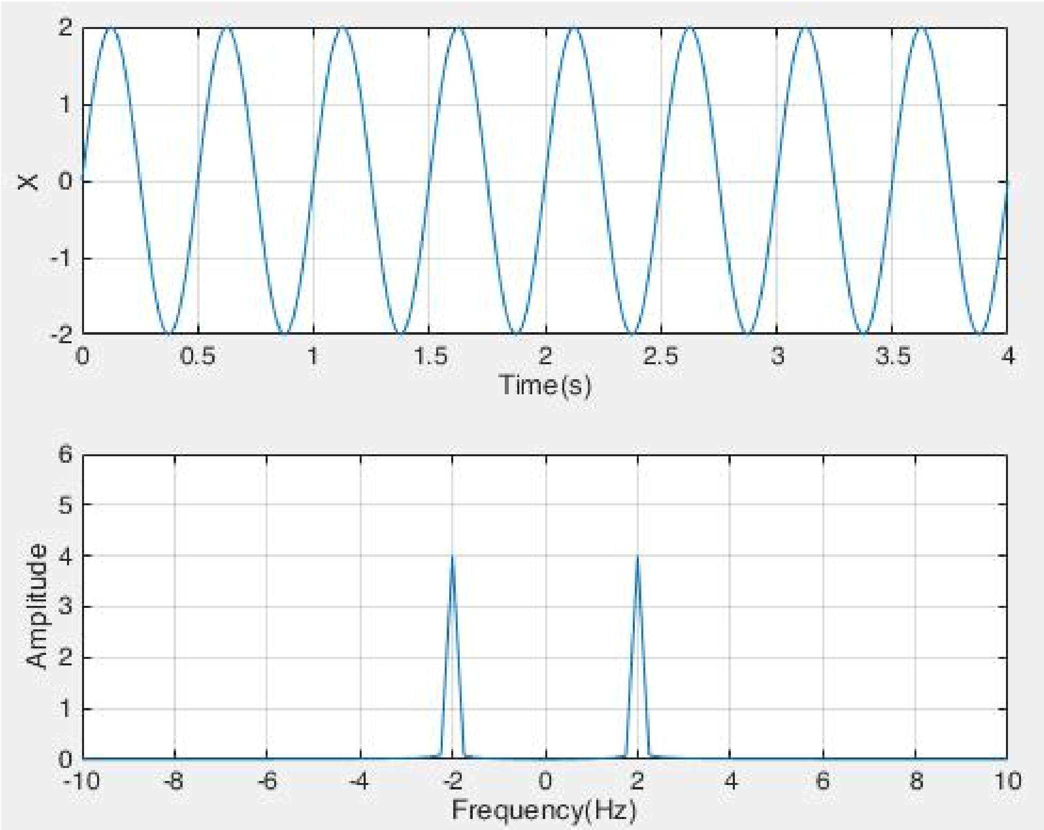

Figure 11

8.1.2 Code

```
% Problem8
dt = 1/100;
et = 4;
t = 0:dt:et;
x = 2*sin(2*2*pi*t);
subplot(2,1,1);plot(t,x);grid on
axis([0 et -2 2]);
xlabel('Time(s)');
ylabel('X');
[f,s] = ft(t,x);
S = abs(s);
subplot(2,1,2);
plot(f,S);grid on
axis([-10 10 0 6]);
xlabel('Frequency(Hz)');
ylabel('Amplitude');
```

Code 14

8.1.3 Interpretation

As can be seen from Figure 10, there are two subplots here. Subplot one is the curve of "X(t)=2sin(2 π t)", and the amplitude and frequency are 2 and 2Hz , respectively. Subplot two is magnitude spectrum of X(t), the Subplot has two pulse signals at (-2,4) and (2,4) , these pulse signals are converted from Fourier transform, The deduced formula is as follows:

$$F[\sin(2\pi f_0 t)] = \frac{j}{2}[\delta(f - f_0) + \delta(f + f_0)] \quad \cdots\cdots\cdots\cdots\cdots \text{(a)}$$

Because there is an imaginary part in the formula, the output result is taken as an absolute value in the code for us to observe more easily.

8.2 Change the length of signal X(t)

8.2.1 Increase the length of signal X(t)

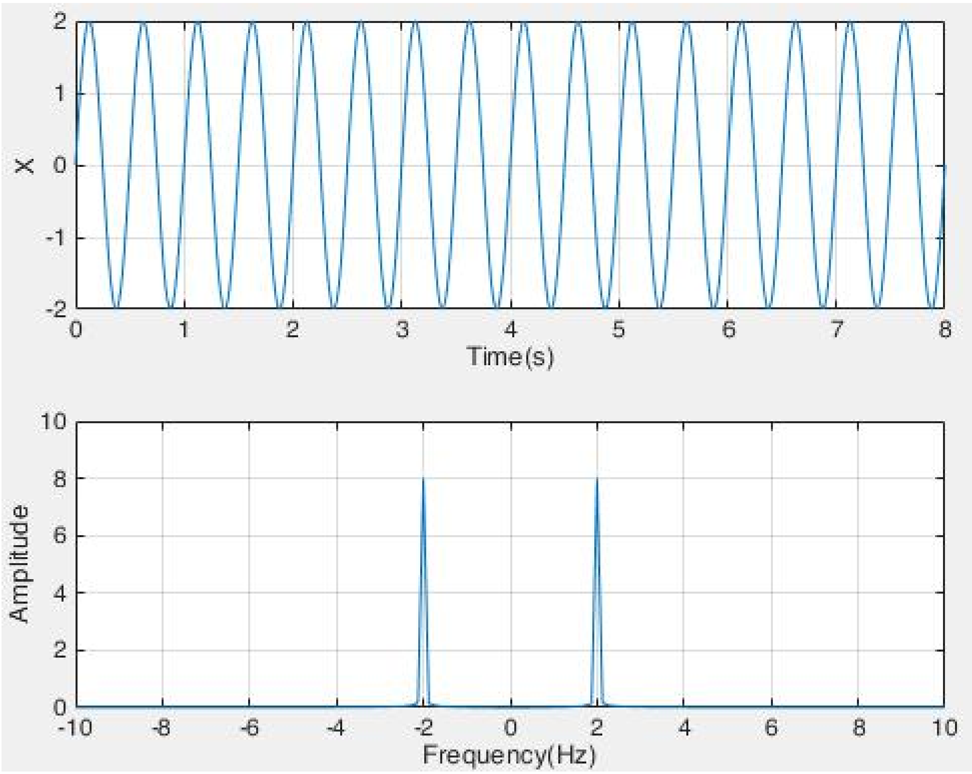

Figure 12 Result

8.2.2 Decrease the length of signal X(t)

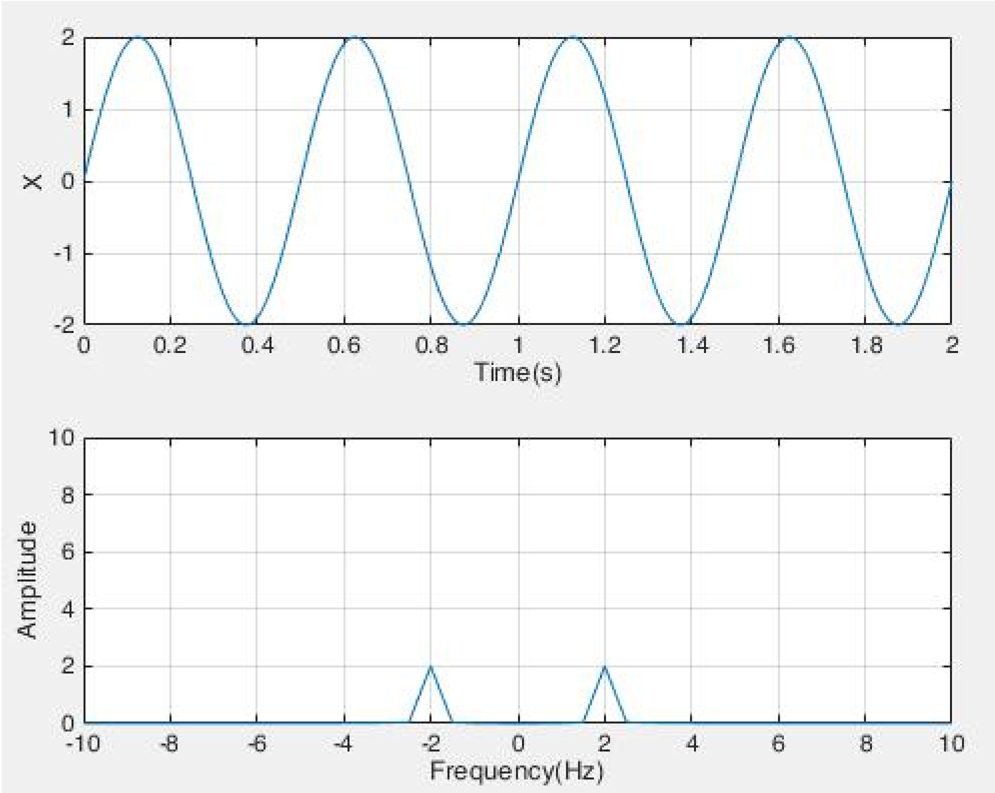

Figure 13 Result

8.2.3 Interpretation

The as seen in Figure 12, when we increase the length of signal X(t) from 4 to 8, the amplitude also increase from 4 to 8. And in Figure 13, the length decrease to 2, the amplitude decrease to 2 too. In a summary, positive correlation between them. Because of Formula(a), the amplitude of single period sin function after Fourier Transform is amplitude of one-half sin signal.

8.3 Change the sampling period of the signal x(t)

8.3.1 Increase the sampling period of the signal x(t)

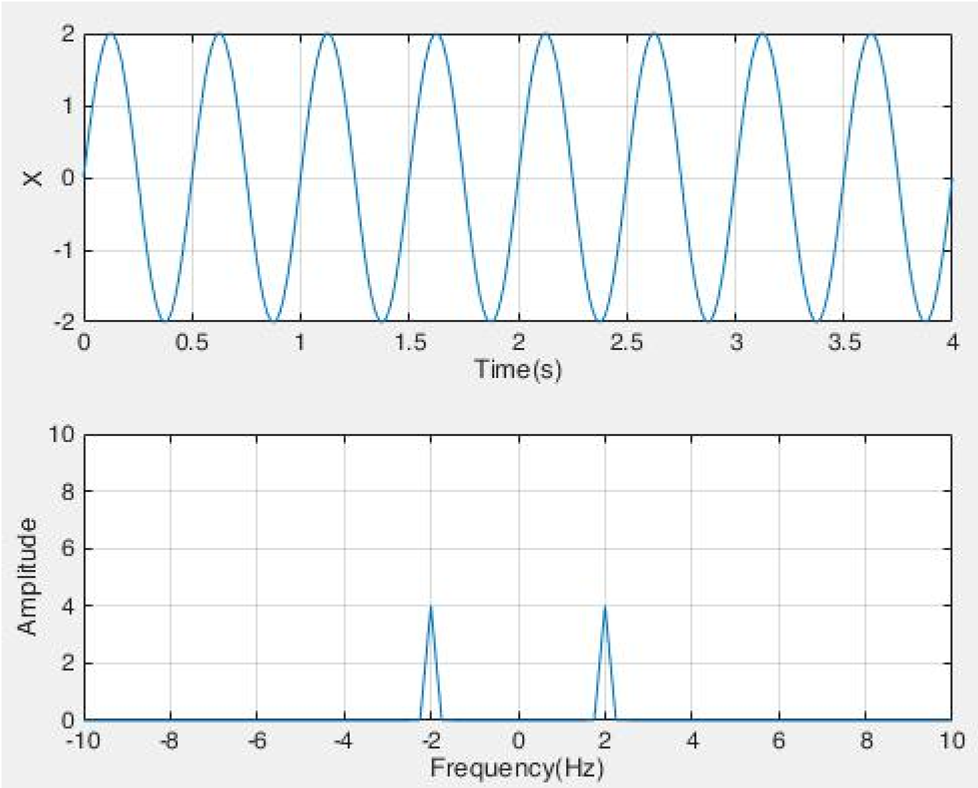

Figure 14 Result

8.3.2 Decrease the sampling period of the signal x(t)

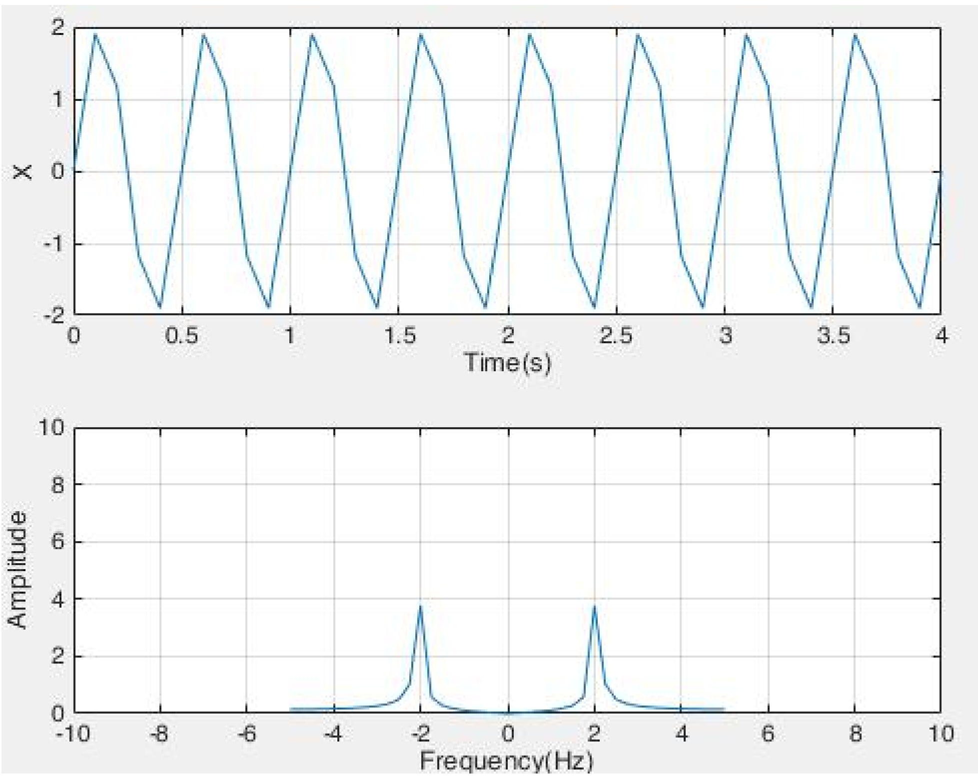

Figure 15 Result

8.3.3 Interpretation

The as seen in Figure 12, when we decrease the sampling period of signal X(t) from 0.01 to 0.001, there was no change in the outcome. And in Figure 13, the sampling period increased from 0.01 to 0.1, the image becomes uneven and the amplitude decreases. This is because the smaller sampling period, the smoother the signal image and more details, in contrast, if the sampling period is too large, the image will be incomplete and the result after Fourier transform will not be accurate.

8.4 Rectangular signal y(t)

8.4.1 Result

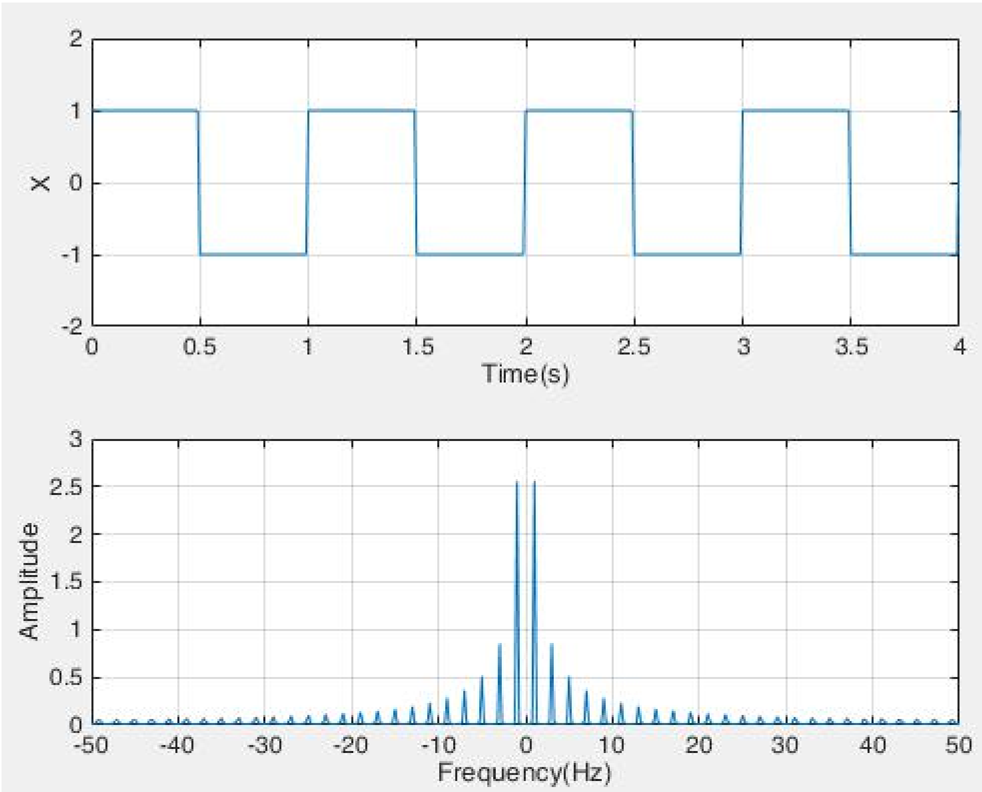

Figure 16 Result

8.4.2 Code

```
% Problem8.1
dt = 1/100;
et = 4;
t = 0:dt:et;
y = square(2*pi*t);
subplot(2,1,1);plot(t,y);grid on
axis([0 et -2 2]);
xlabel('Time(s)');
ylabel('X');
[f,s] = ft(t,y);
S = abs(s);
subplot(2,1,2);
plot(f,S);grid on
xlabel('Frequency(Hz)');
ylabel('Amplitude');
```

Code 15

8.4.3 Interpretation

Rectangular signal y(t) is decomposed into Y(t) by Fourier series, it was shown as below:

$$\mathrm{Y}(t) = \frac{4}{\pi}[\sin 2\pi t + \frac{1}{3}\sin 6\pi t \frac{1}{5}\sin 10\pi t + \cdots + \frac{1}{n}\sin 2n\pi t + \cdots] \quad \cdots\cdots\cdots \quad \text{(b)}$$

$n = 1,3,5,\cdots$

Fourier transforms of the above sin functions are carried out respectively, and the results are shown in the figure16.