深 圳 大 学 实 验 报 告

课程名称：医学数字信号处理

实验项目名称：**FFT 算法分析信号频谱**

学院：医学院

专业：生物医学工程

指导教师：刁现芬

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实验时间：**2018-11-9**

实验报告提交时间：**2018-11-14**

教务部制

实验目的与要求：

1、 理解 DFT 变换进行频谱分析的理论；

2、 学会对常用信号进行频谱分析。

实验内容：

1. 根据所讲授的信号频谱分析理论，读懂所给的频谱分析例子代码，并分析不同数据长度对频谱分析影响。
2. 教材 173 页，习题 P5.26。
3. 对所给的超声回波信号进行频谱分析，采样频率40MHz，绘制出幅度谱、相位谱；

频谱分析例子：

```
clear all
clc
fs = 1000;% sampling frequency
T =1/fs;
t = 0:T:1;
%N= 256;
%N = 512;% data length for FFT
N = 1024;
%N = 1000;
%N=2048;1*randn(size(t));
x = sin(2*pi*50*t)+sin(2*pi*100*t)+0.5*randn(size(t));
plot(1000*t(1:200),x(1:200));
title('x(t)');
xlabel('t/(ms)');
X = fft(x,N);
Mag_X = abs(X);
f = fs*(0:N/2)/N;
figure;
plot(f,Mag_X(1:N/2+1));
xlabel('f/(Hz)');
ylabel('幅度 |X(k)|');
```

程序代码及运行结果：

1.

```
clear all
clc
fs = 1000;% sampling frequency
T =1/fs;
t = 0:T:1;
%N= 256;
%N = 512;% data length for FFT
%N = 1024;
%N = 1000;
N=2048;
x = sin(2*pi*50*t)+sin(2*pi*100*t)+0.5*randn(size(t));
plot(1000*t(1:200),x(1:200));
%title('$y=e^{-at}$', 'fontsize',16,'interpreter', 'latex');
title('$x(n)=sin100{\pi}t+sin200{\pi}t+noise$','Interpreter','late
x');
xlabel('t/(ms)');
X = fft(x,N);
Mag_X = abs(X);
f = fs*(0:N/2)/N;
figure;
plot(f,Mag_X(1:N/2+1));
title('对 x(n)做傅里叶变换');
xlabel('f/(Hz)');
ylabel('幅度谱|X(k)|');
hold on
if N == 256
    gtext('N=256');
elseif N ==512
    gtext('N=512');
elseif N==1024
    gtext('N=1024');
elseif N==1000
    gtext('N=1000');
elseif N==2048
    gtext('N=2048');
end
```

N=256

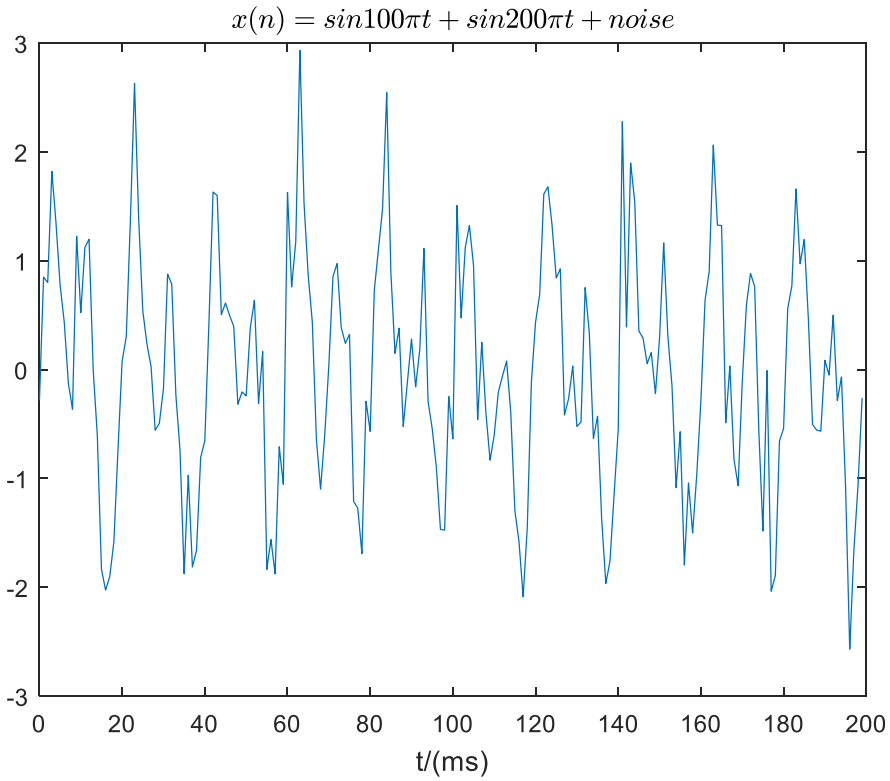
$x(n) = sin100\pi t + sin200\pi t + noise$
3
2
1
0
-1
-2
-3
0
20
40
60
80
100
120
140
160
180
200
t/(ms)

图 1-1

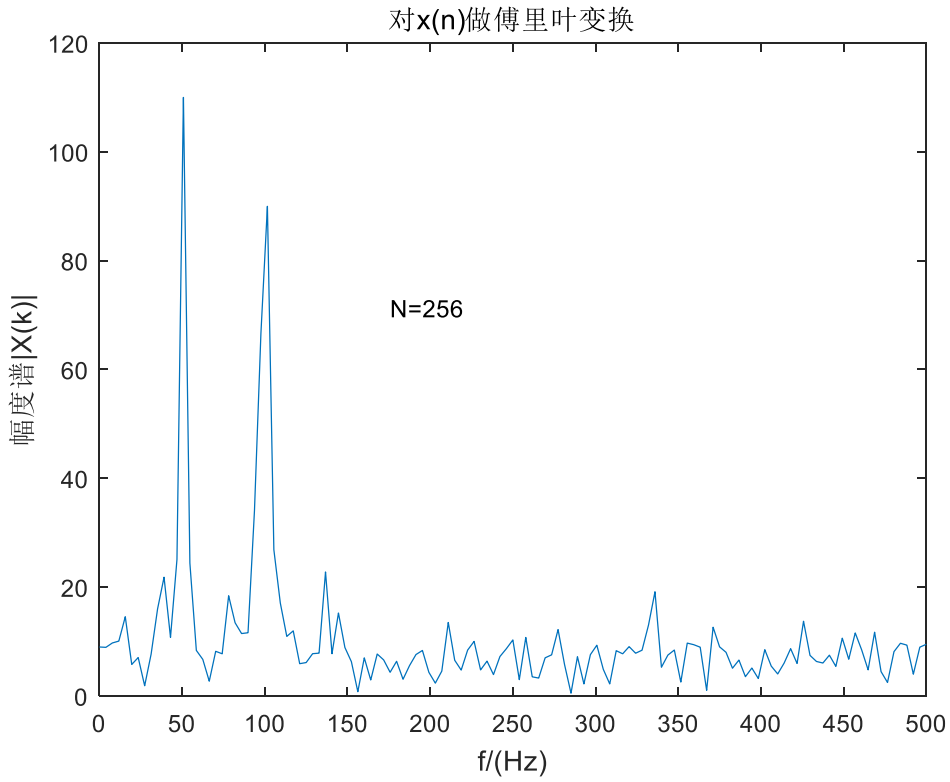
对x(n)做傅里叶变换
幅度谱|X(k)|
N=256
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
400
450
500
f/(Hz)

图 1-2

N=512

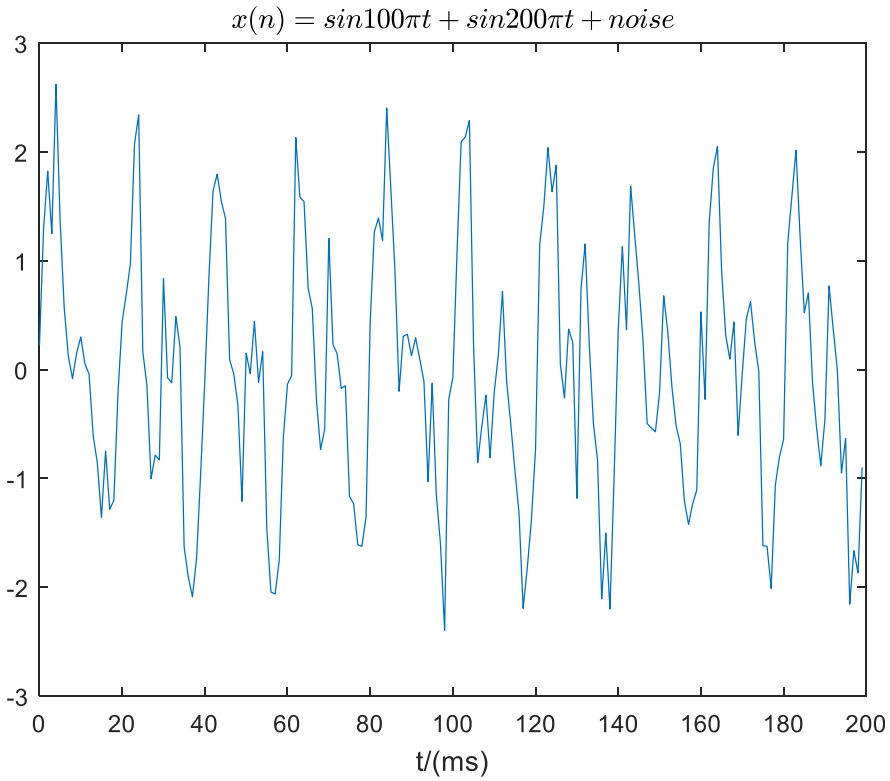
$x(n) = sin100\pi t + sin200\pi t + noise$
3
2
1
0
-1
-2
-3
0
20
40
60
80
100
120
140
160
180
200
t/(ms)

图 1-3

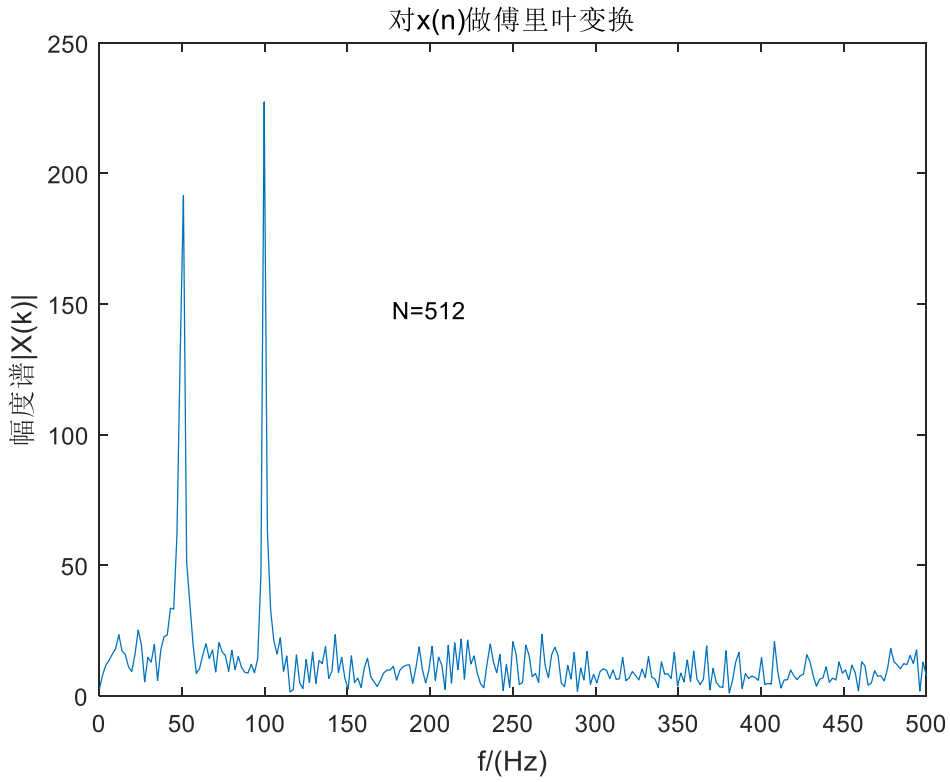
对x(n)做傅里叶变换
250
200
150
100
50
0
幅度谱|X(k)|
N=512
0
50
100
150
200
250
300
350
400
450
500
f/(Hz)

图 1-4

N=1024

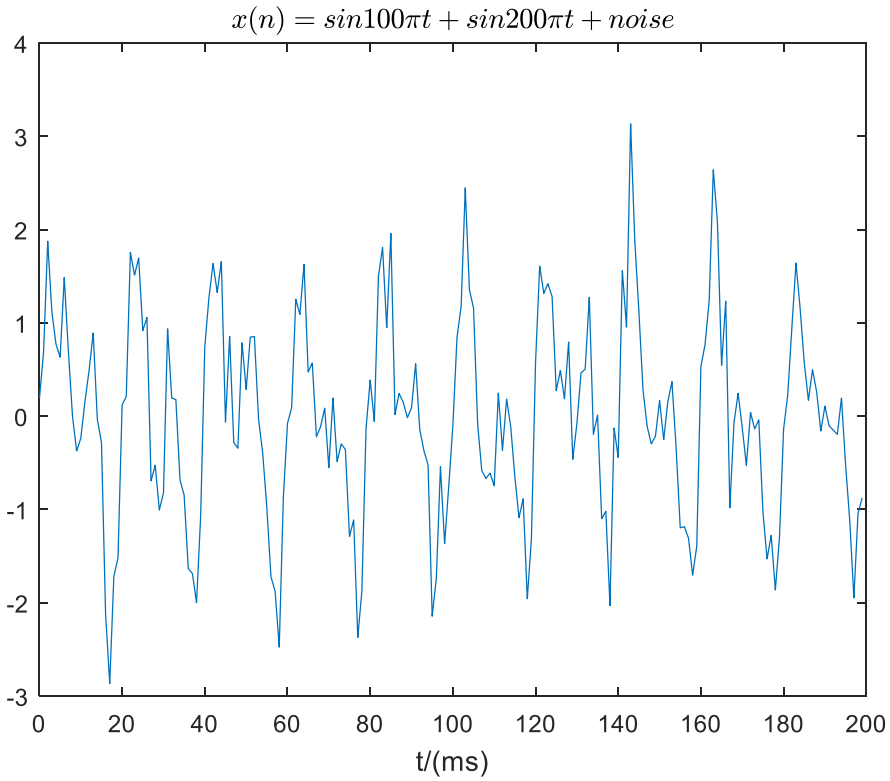

图 1-5

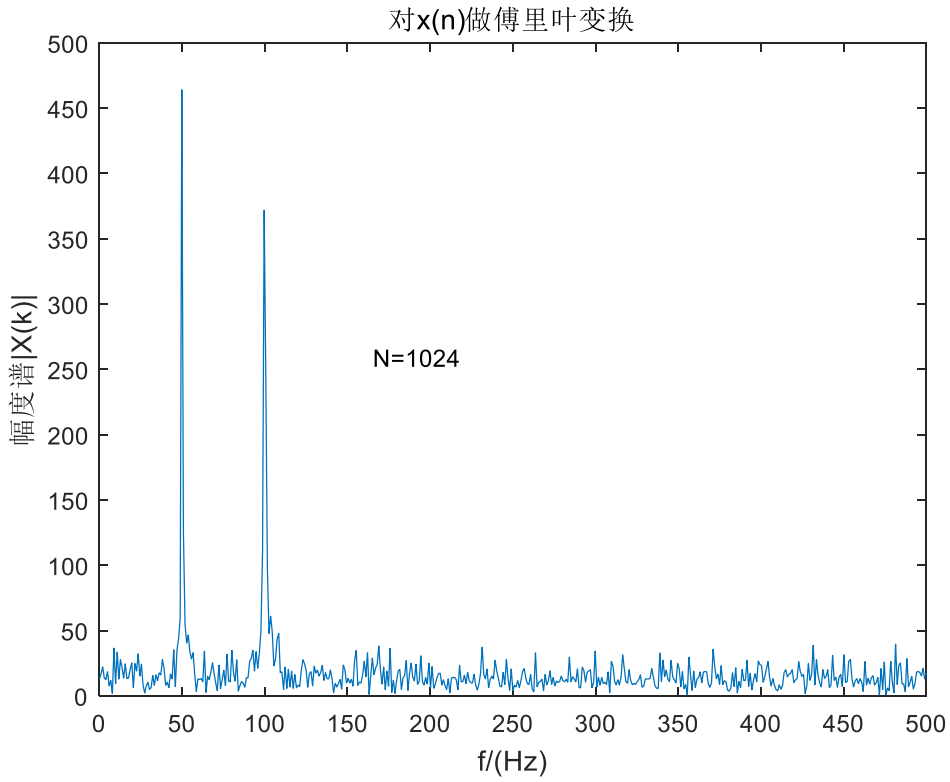

图 1-6

N=1000

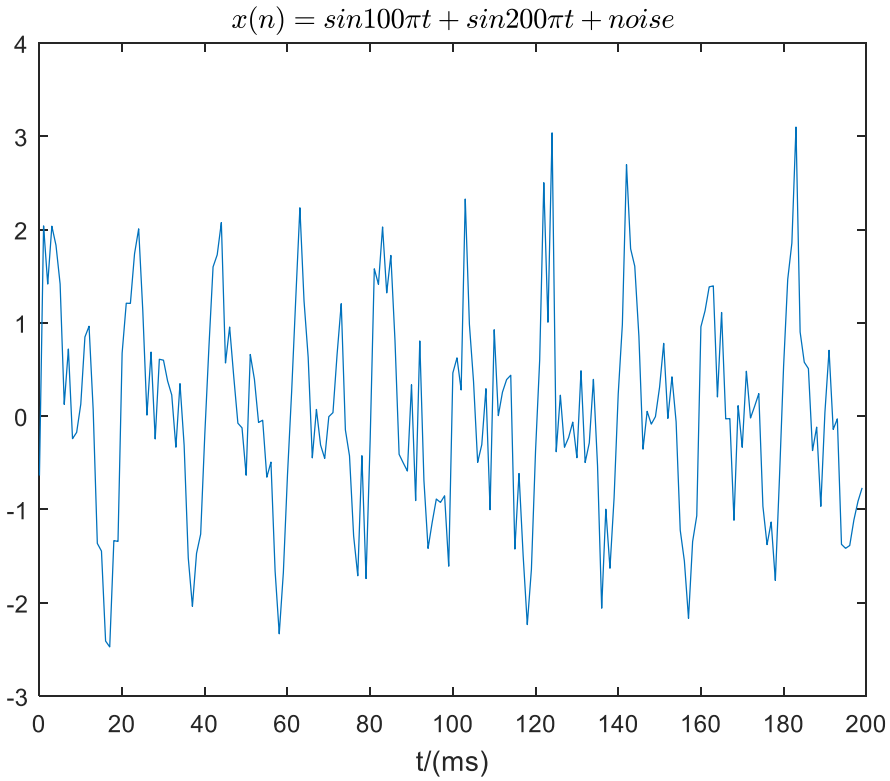

图 1-7

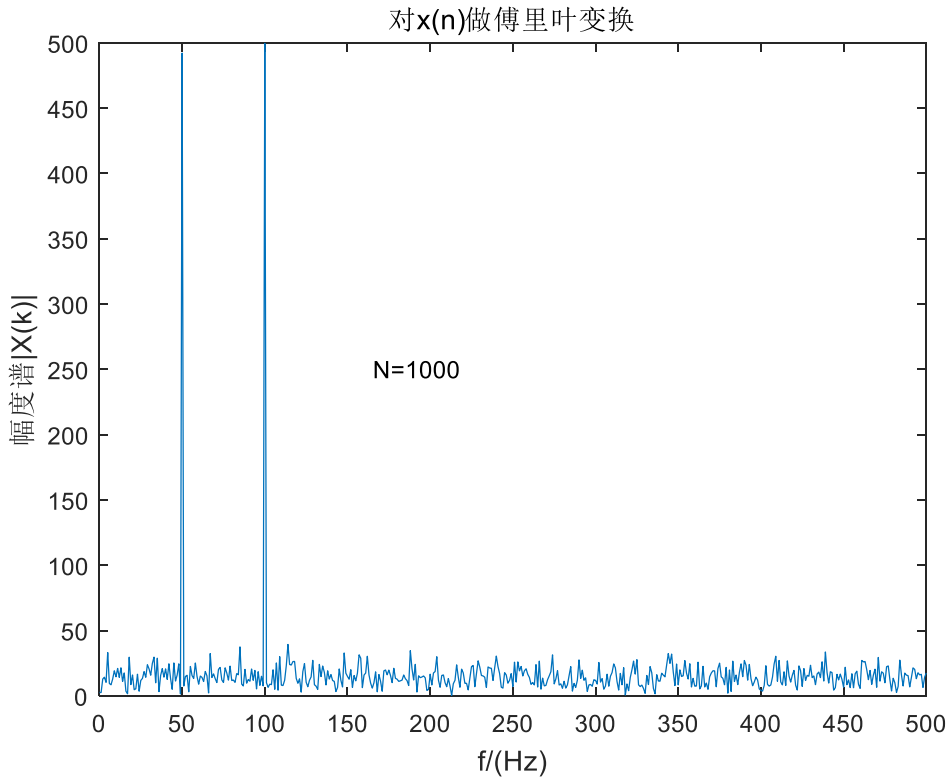

图 1-8

N=2048

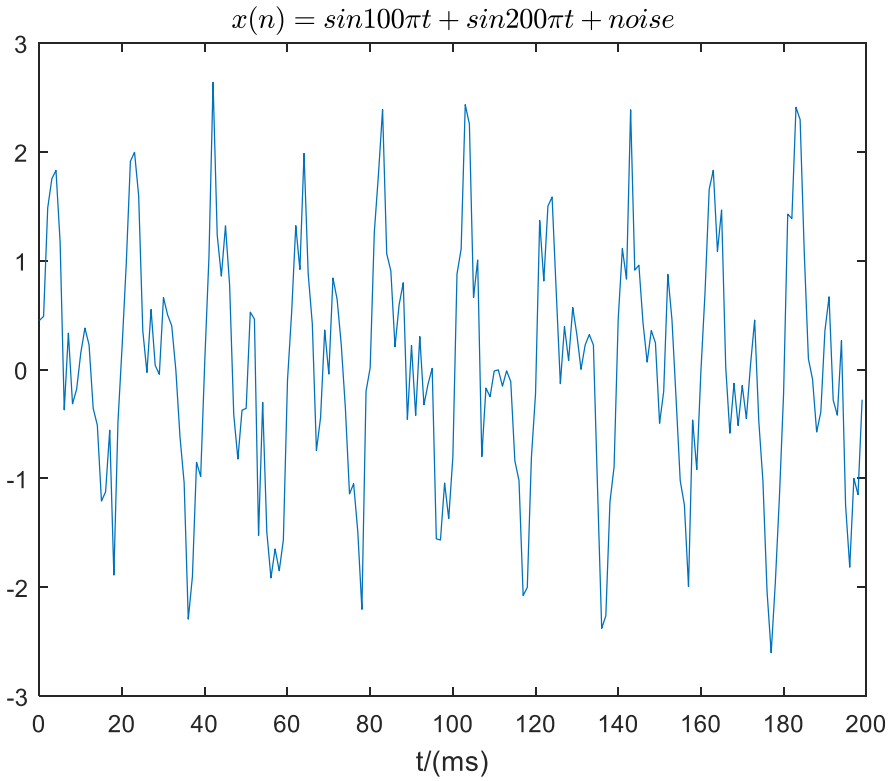

图 1-9

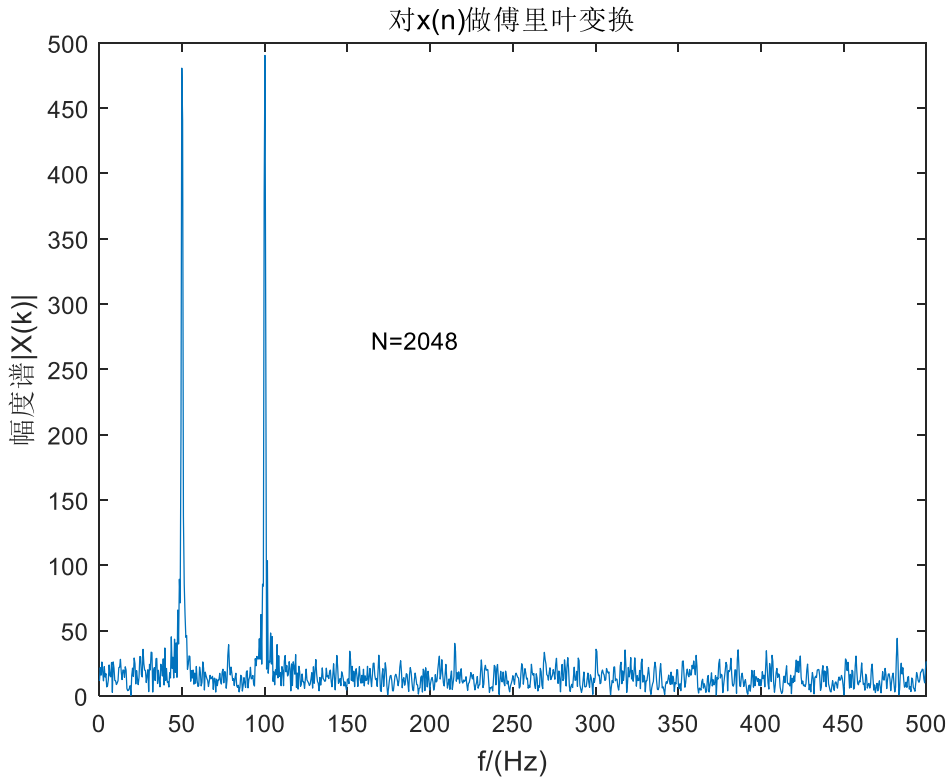

图 1-10

2.

程序代码如下：

```
clc;clear;close all

fs = 100;
n = 0:1:fs-1;
t =  0.01*n;
xa = 2*sin(4*pi*t)+5*cos(8*pi*t);
figure;
plot(t*100,xa);
title('$x(n)=2sin4{\pi}t+5cos8{\pi}t$','Interpreter','latex');
xlabel('t/(ms)');

N = 60;
n = 0:N-1;
Xa = fft(xa, N);
Mag_Xa = abs(Xa);
f = fs*(0:N/2)/N;
figure;
stem(f, Mag_Xa(1:N/2+1));
xlabel('f/(Hz)')
ylabel('幅度谱 X(k)|');
hold on
if N == 40
    gtext('N=40');
elseif N == 50
    gtext('N=50');
elseif N == 60
    gtext('N=60');
end
hold off;
real_Xa = real(Xa);
imag_Xa = imag(Xa);
figure
subplot(2,1,1);
plot(f,real_Xa(1:N/2+1));
title('Real Part');
xlabel('frequency /Hz');
ylabel('Real');

subplot(2,1,2);
plot(f,imag_Xa(1:N/2+1));
title('Imaginary Part');
xlabel('frequency /Hz');
```

```
ylabel('Imaginary');
```

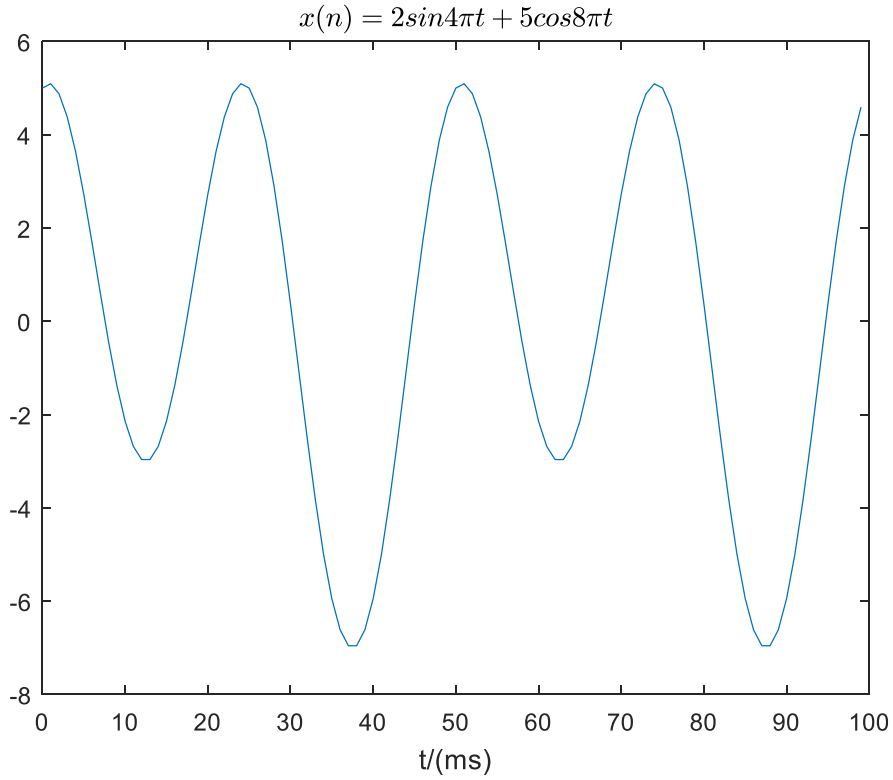

图 2-1

N=40

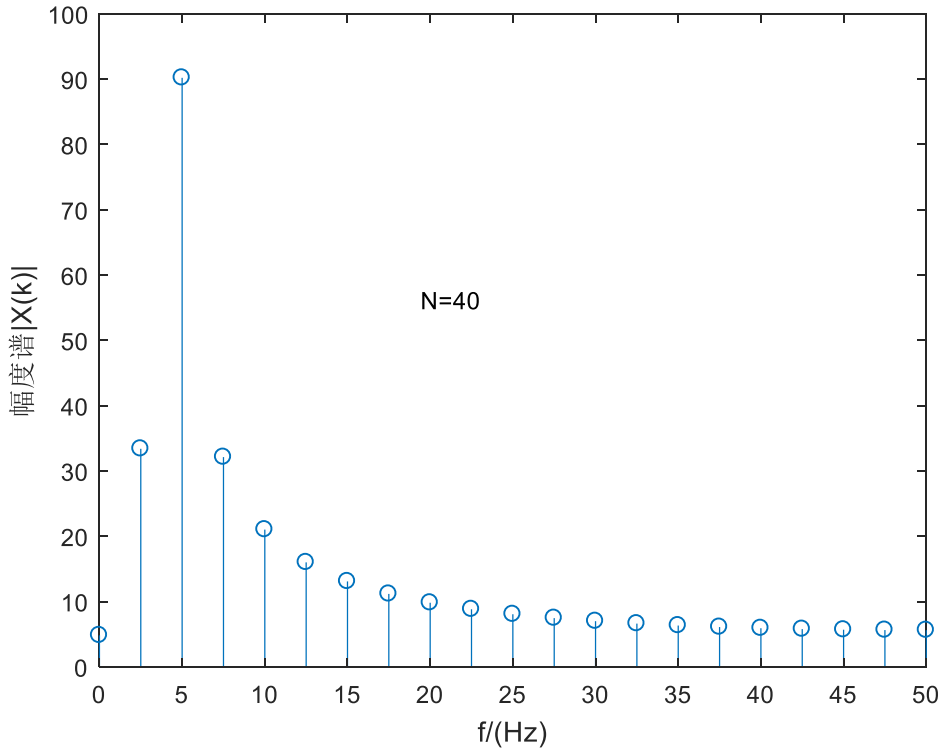

图 2-2

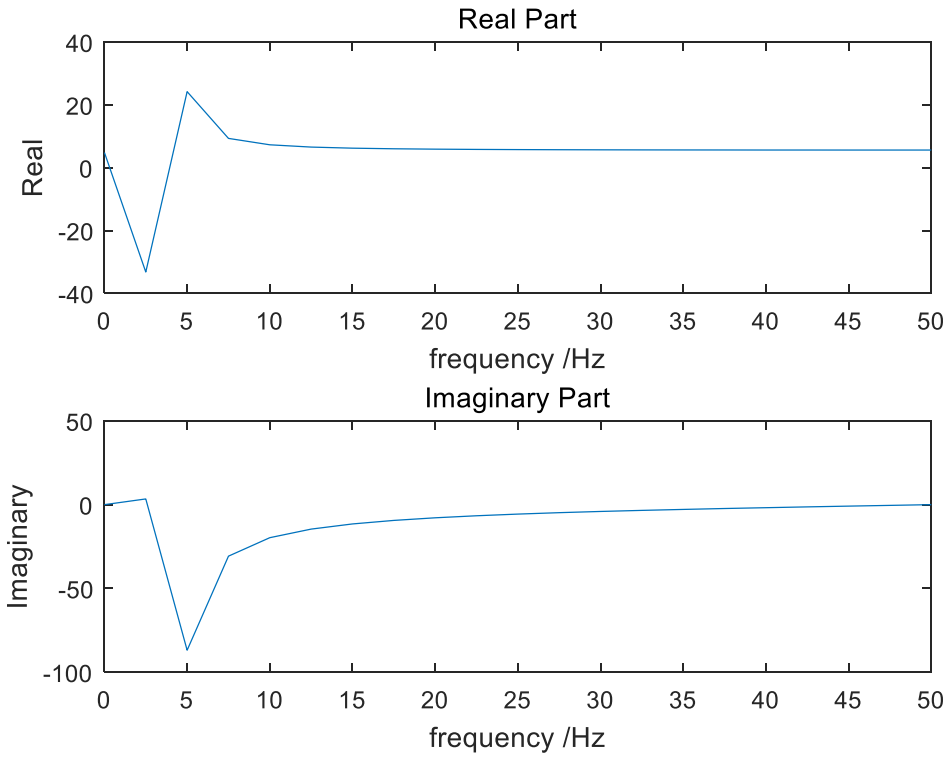
Real Part
Real
frequency /Hz
Imaginary Part
Imaginary
frequency /Hz

图 2-3

N=50

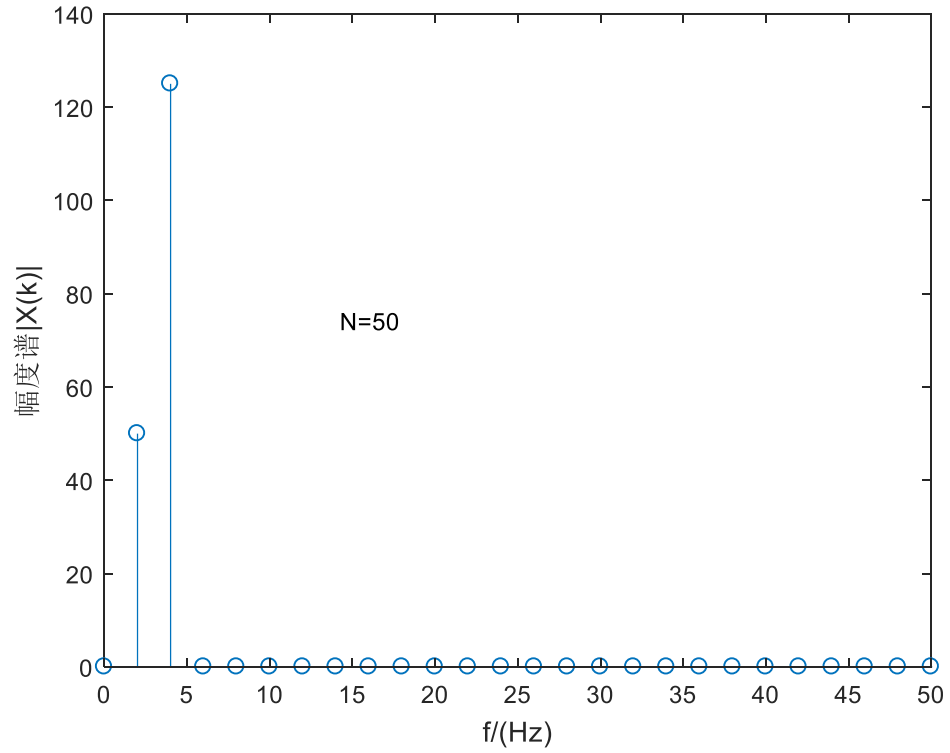
幅度谱|X(k)|
N=50
f/(Hz)

图 2-4

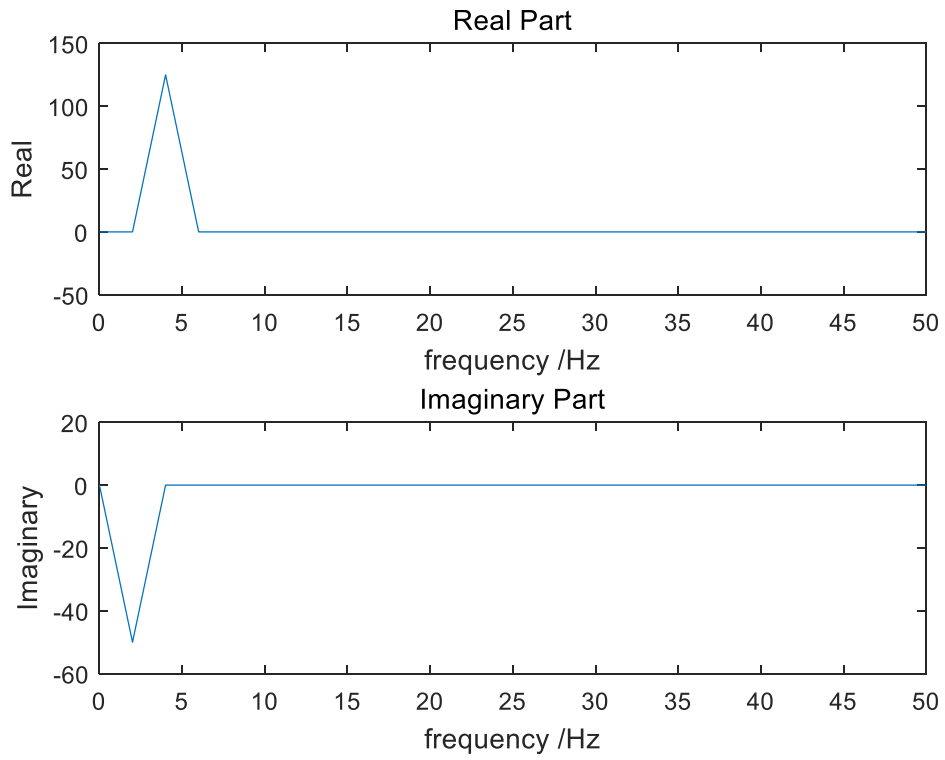
Real Part
Real
frequency /Hz
Imaginary Part
Imaginary
frequency /Hz

图 2-5

N=60

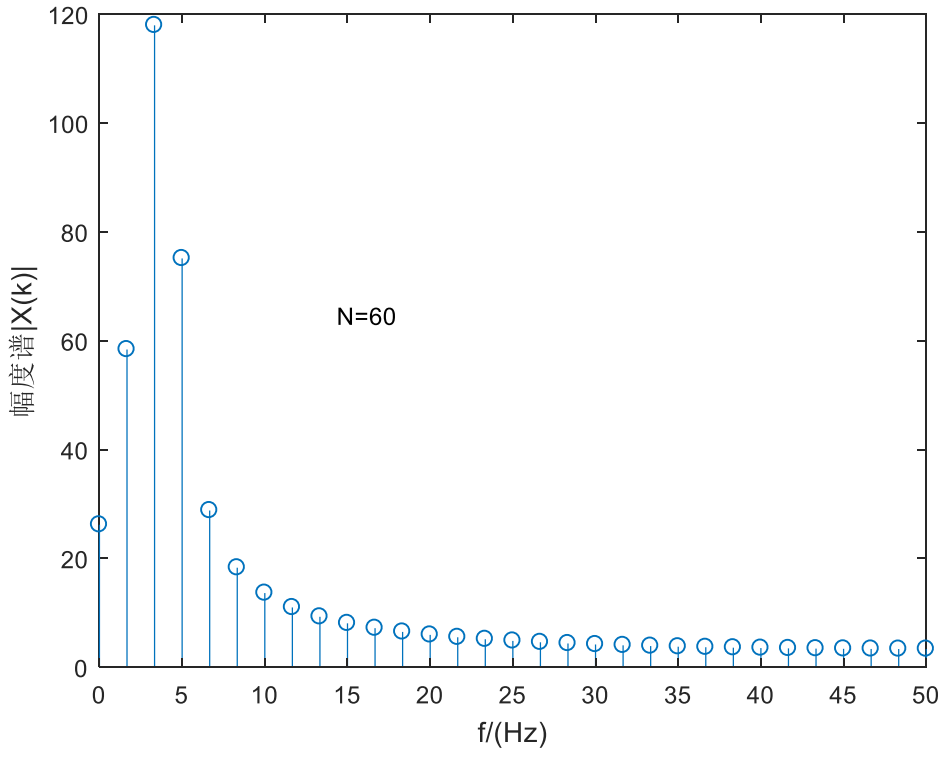
N=60
幅度谱|X(k)|
f/(Hz)

图 2-6

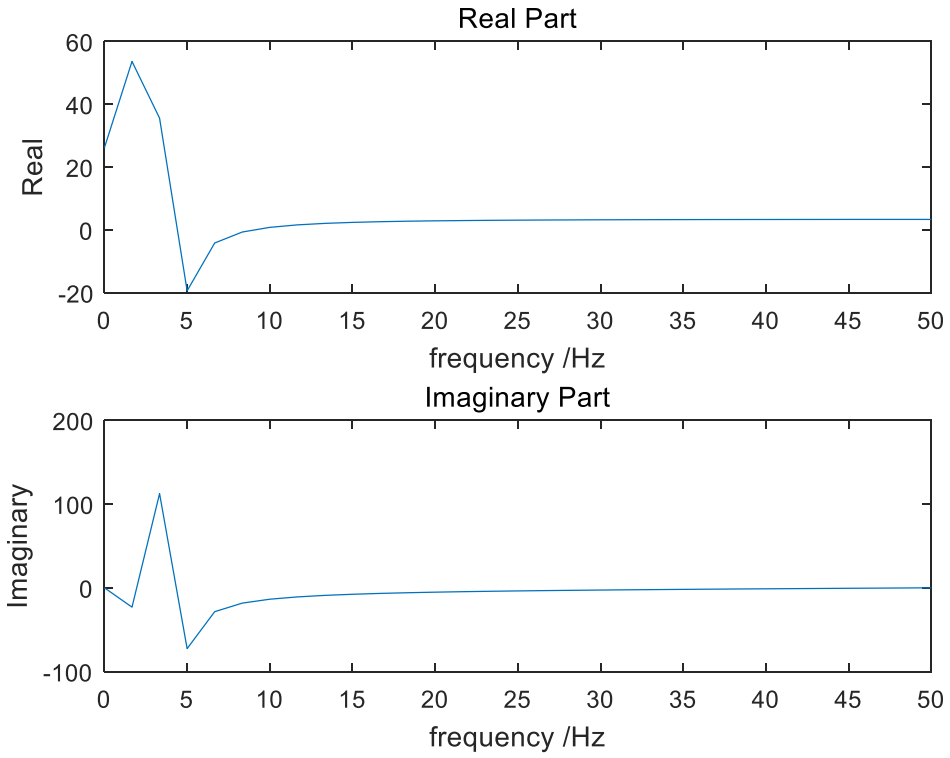
Real Part
Real
frequency /Hz
Imaginary Part
Imaginary
frequency /Hz

图 2-7

N = 90

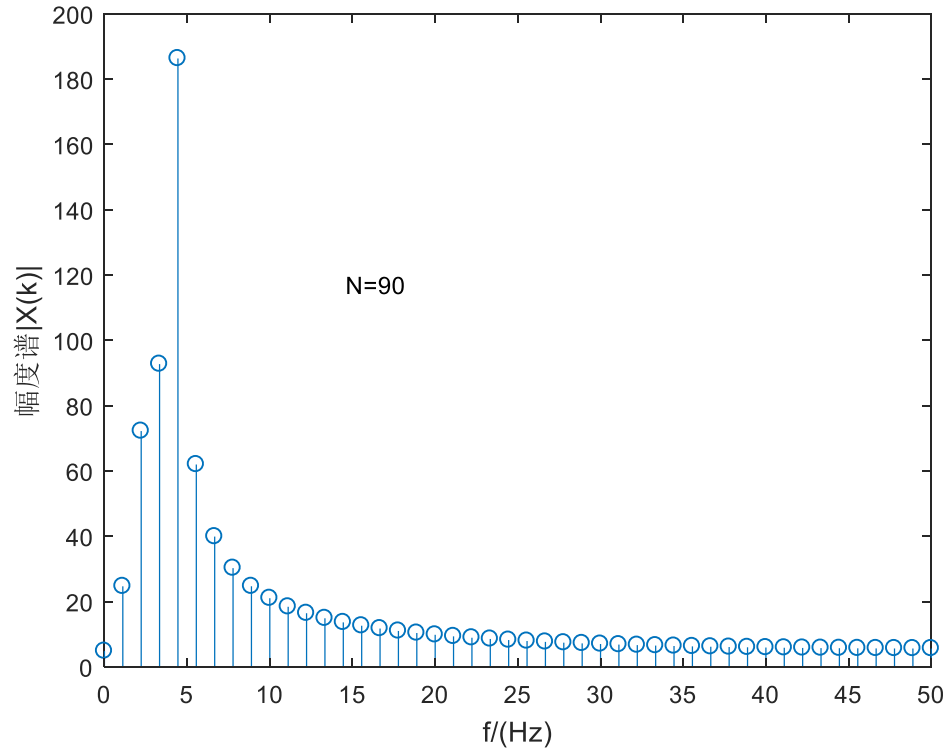
N=90
幅度谱|X(k)|
f/(Hz)

图 2-8

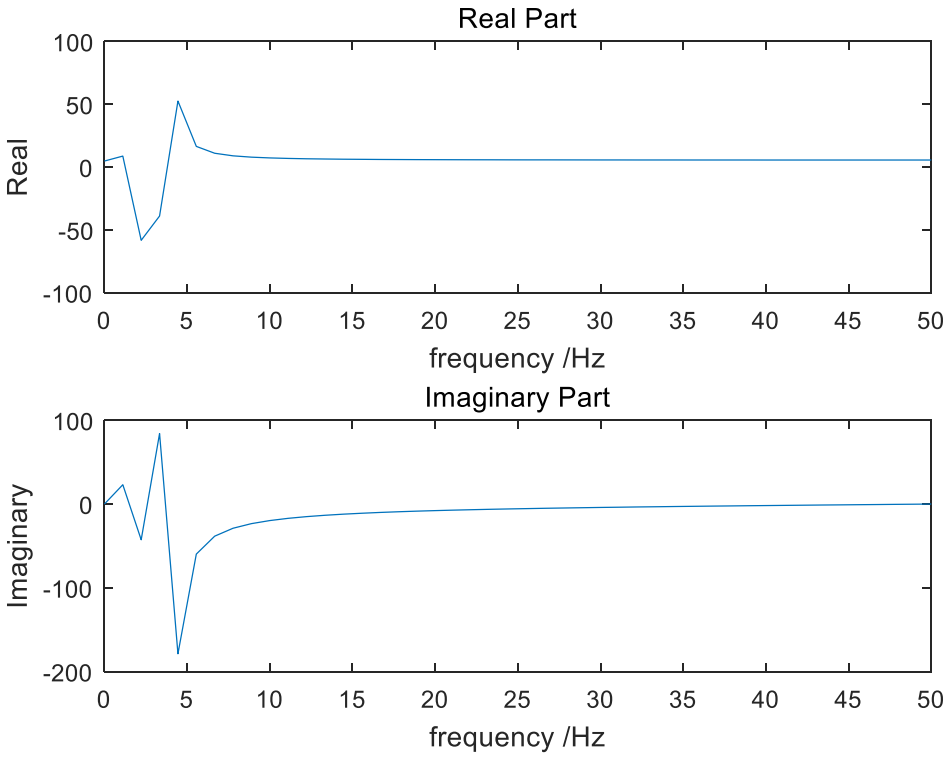
Real Part
Real
frequency /Hz
Imaginary Part
Imaginary
frequency /Hz

图 2-9

N=95

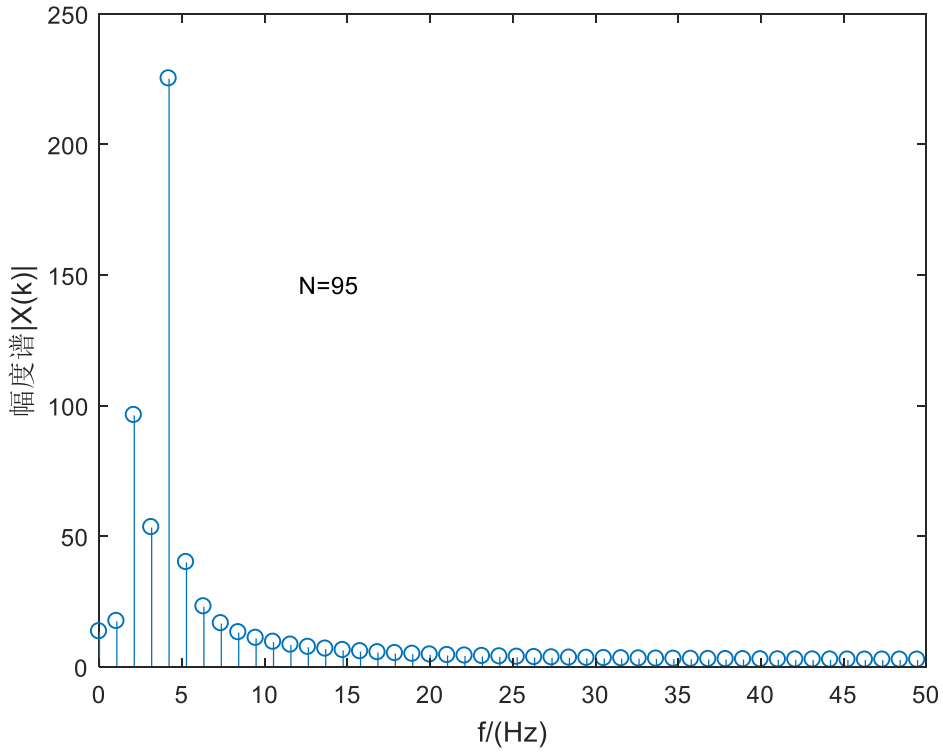
N=95
幅度谱|X(k)|
f/(Hz)

图 2-10

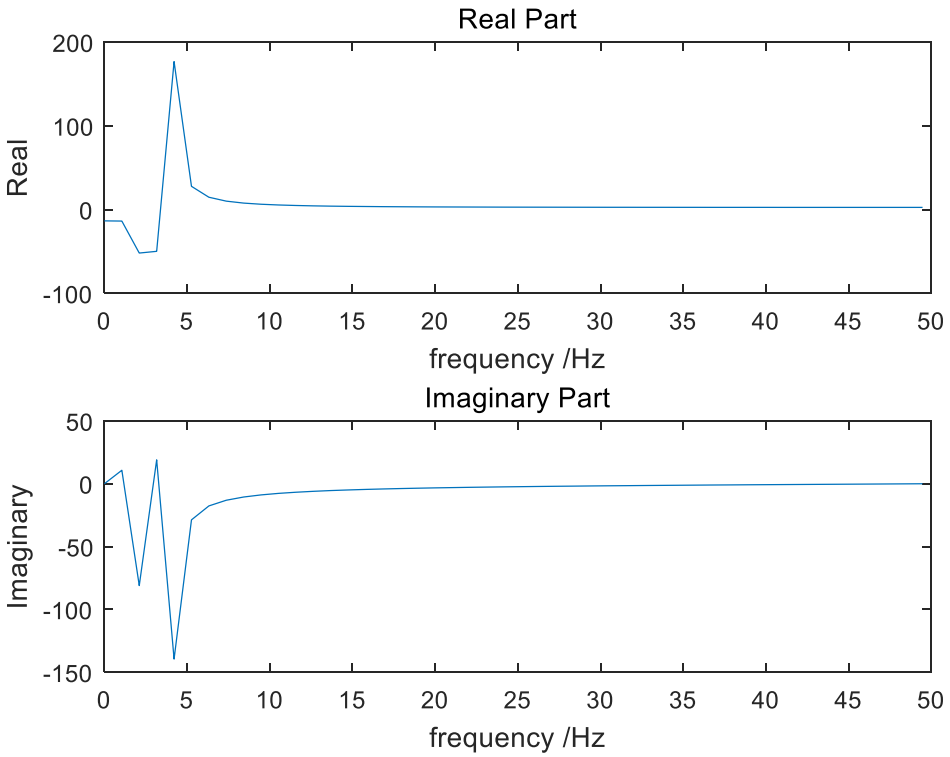

图 2-11

N=99

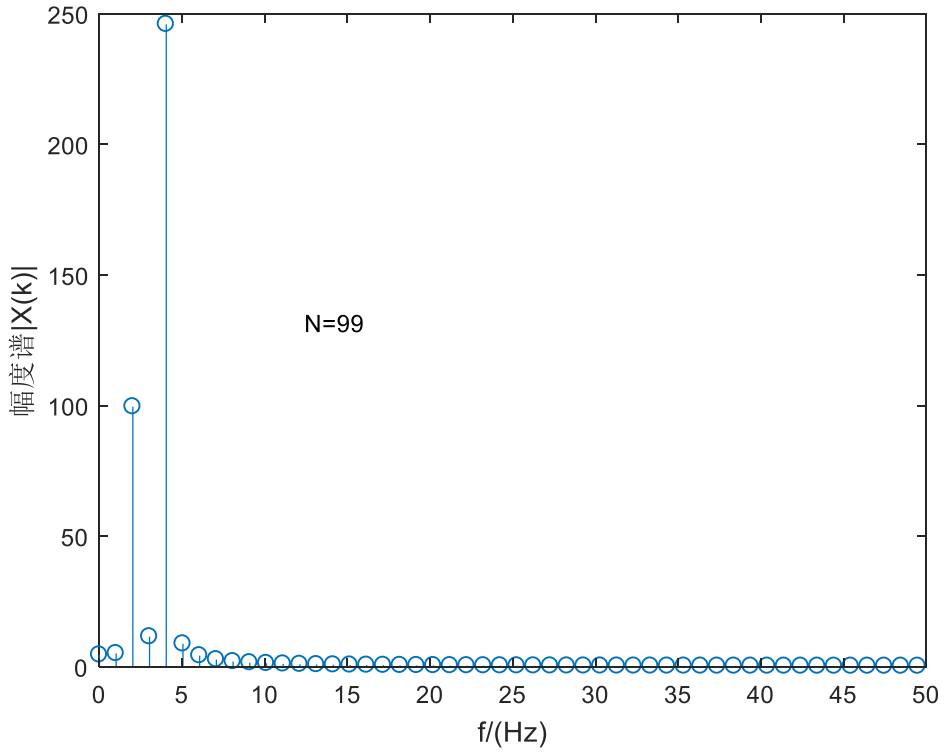

图 2-12

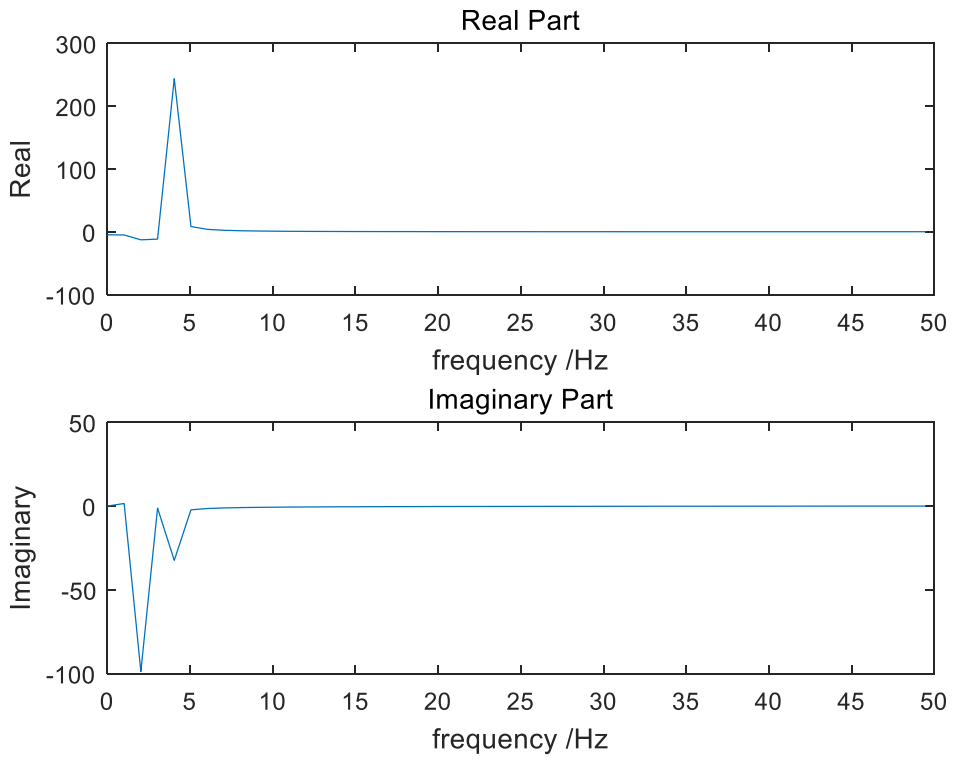

图 2-13

3.

程序代码如下所示：

```
clc;clear;close all;

load ALine.mat;
N = length(x);

fs = 40e6;
T  = 1/fs;
t  = 0:T:T*(N-1);
plot(t*1e6,x);
title('Supersonic echo wave')
xlabel('t/(us)');
hold on
gtext('Frequence:40MHz');
hold off;

f = fs * (0:N/2)/N;
X = fft(x);
```

```
mag_X = abs(X);
figure
subplot(2,1,1);
plot(f/1e6, mag_X(1:length(f)));
title('Magnitude Part');
xlabel('f/(MHz)');
ylabel('Magnitude |X(k)|');

ang_X = angle(X);
subplot(2,1,2);
plot(f/1e6, ang_X(1:length(f)));
title('Angle Part');
xlabel('f/(MHz)');
ylabel('Radians $${\langle}X(k)$$','Interpreter','latex');
```

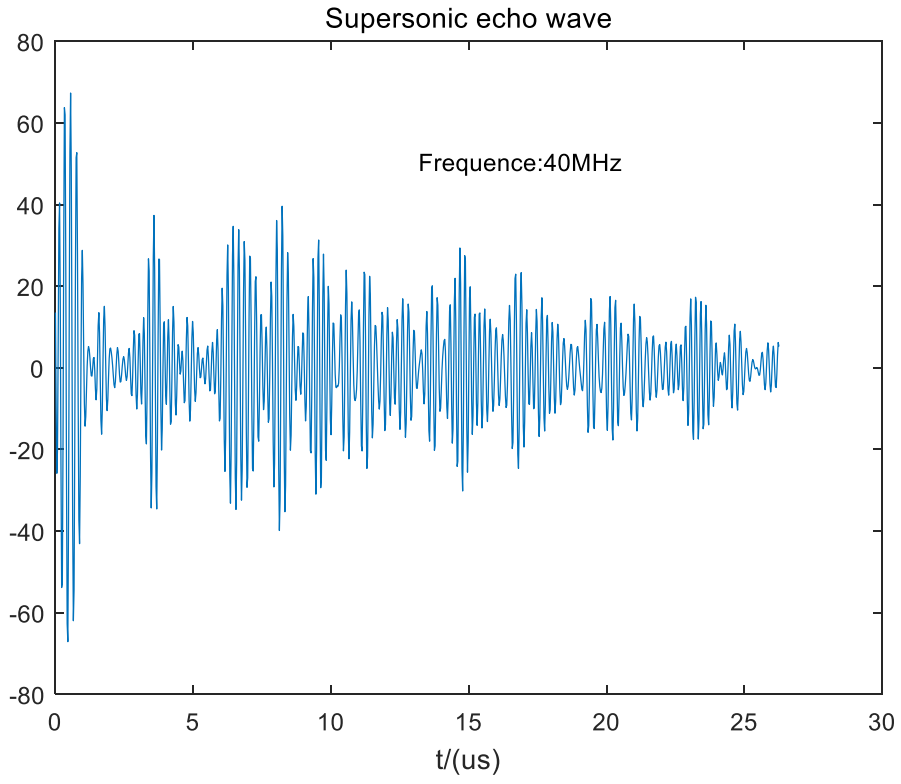

图 3-1

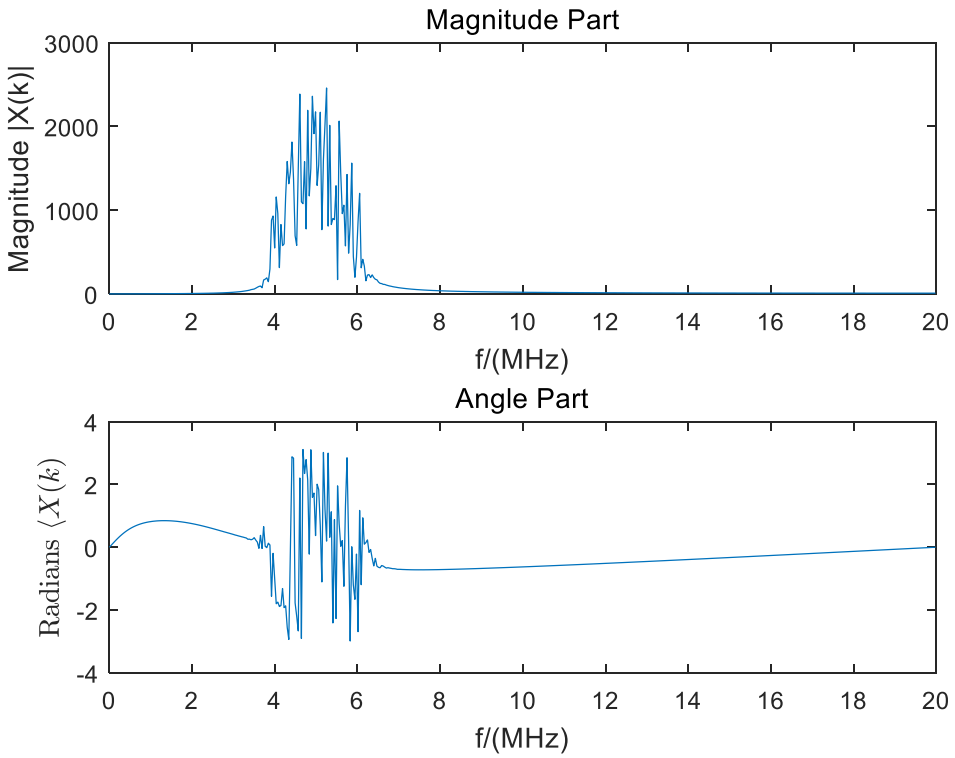

图 3-2

实验结论：

（1） 采样的频率越高，得到的采样点就越多，做 DFT 进行频谱分析得到的结果就越准确。

（2） 通过这次实验我理解如何利用 DFT 变换进行频谱分析的理论；

（3） 学会了对常用信号进行频谱分析。

指导教师批阅意见： 成绩评定： 指导教师签字： 年　　月　　日
备注：

注：1、报告内的项目或内容设置，可根据实际情况加以调整和补充。

2、教师批改学生实验报告时间应在学生提交实验报告时间后 10 日内。