Glasgow College, UESTC

Digital Signal Processing

Homework 2

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HOMEWORK 2

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CONTENTS

INTRODUCTION

This report is the homework that should be finished on the MATLAB, there are three questions about Digital Signal Processing. The first question is to generate the DTFP function and plot the real, imaginary part and the magnitude and phase spectrum of it. The last two questions of the homework require us to finish the proof of the DTFT property of a real or complex sequence.

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LIST OF FIGURES

1 PROBLEM M3.1

Generating the following DTFT equation and plot the real, imaginary part and the magnitude and phase spectrum of the following DTFT, by using different parameters:

For solving this question, I review the programs written by myself before[1]. Than, I plot and generate the DTFT by using different parameters and plot the real, imaginary part and the magnitude and phase spectrum of it, shown as Figure 1 and Figure 2.

```
% Author: Changgang Zheng
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clear
clc
r = 0.9;
seita = 0.75;
syms w
range = [0:0.01:3.14];
G= 1/(1-2*r*(cos(seita)*exp(-1j*w))+r^2*exp(-2*1j*w));
G=subs(G,w,range);

figure;
subplot(2,2,1);
R=plot(range,real(G),'LineWidth',1,'color',[1,0.5,0.5]);
xlabel('w/pi')
ylabel('Real part of G(f)')
grid minor

subplot(2,2,2);
```

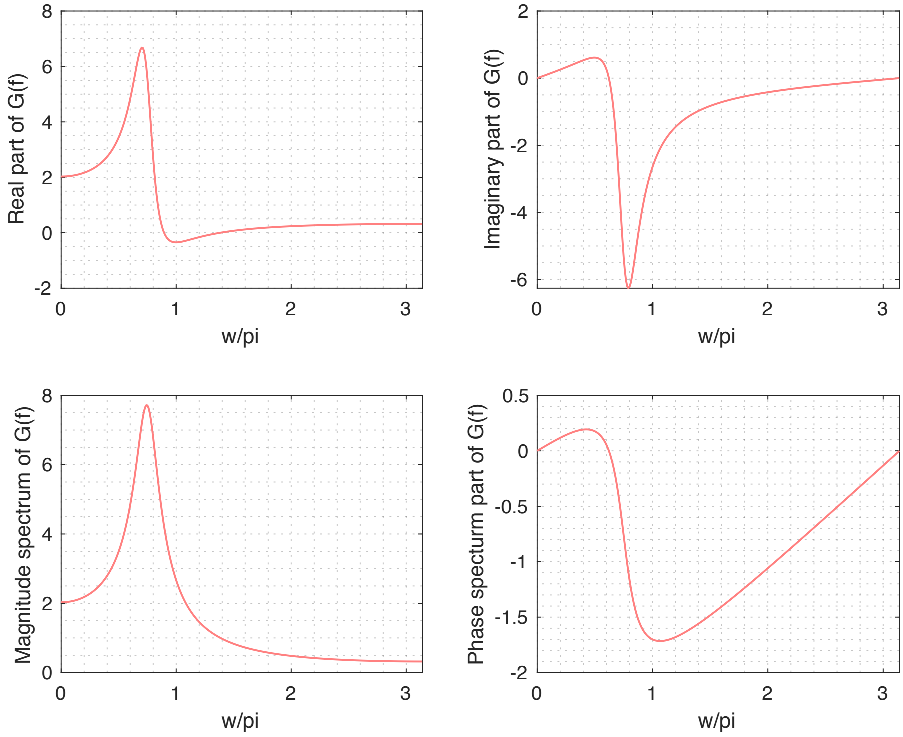

Figure 1: The r equals to 0.9 and θ equals to 0.75

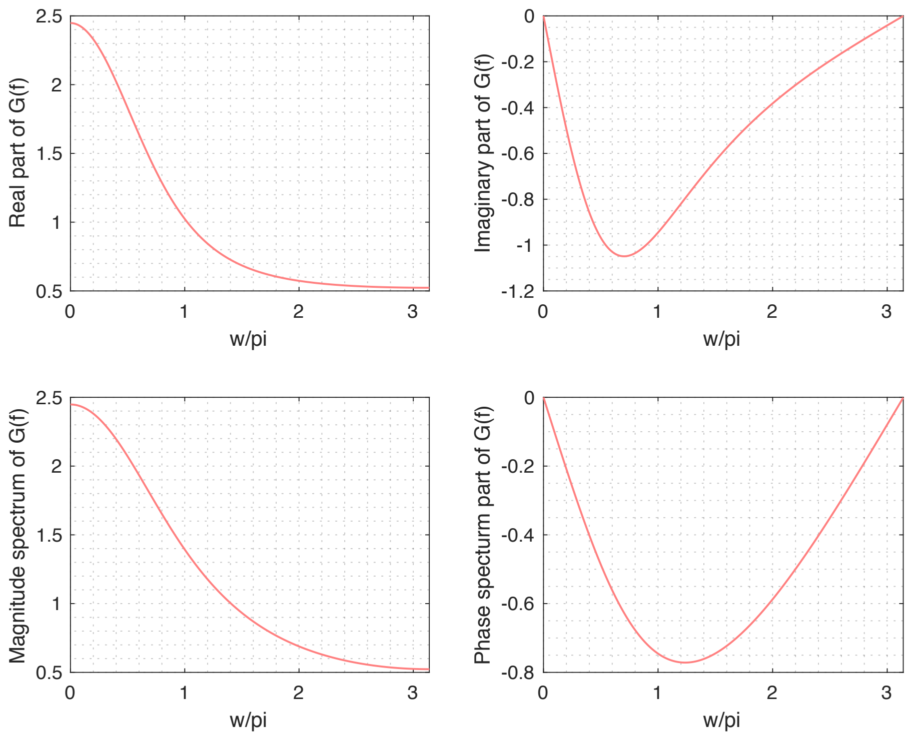

Figure 2: The r equals to 0.4 and θ equals to 0.35

```
IM=plot(range,imag(G),'LineWidth',1,'color',[1,0.5,0.5]);
xlabel('w/pi')
ylabel('Imaginary part of G(f)')
grid minor

subplot(2,2,3);
IM=plot(range,abs(G),'LineWidth',1,'color',[1,0.5,0.5]);
xlabel('w/pi')
ylabel('Magnitude spectrum of G(f)')
grid minor

subplot(2,2,4);
IM=plot(range,angle(G),'LineWidth',1,'color',[1,0.5,0.5]);
xlabel('w/pi')
ylabel('Phase specturm part of G(f)')
grid minor

%saveas(IM,'/Users/changgang/Desktop/problem_3_5.pdf')
```

2 PROBLEM M3.4

Using the matlab to verify the symmetry relations of DTFT of real sequence as listed in Table 3-1:

For solving this question, I first define a real sequence as shown in the following programs. The function is shown as follows: $x = 5.5\sin(20\pi t) + 3.5\cos(10\pi t)$

Note that the tested sequence can be modified which would not influence the final conclusion.

```
% Author: Changgang Zheng
% UESTC ID: 2016200302027
% UoG ID: 2289258z
clear;
clc;

fs=100; % sampling frequency;
N=1024;% sampling points number;
n=[0:N-1]; %order sequence;
t=n/fs; % time sequence;
x=5.5*sin(20*pi*t)+3.5*cos(10*pi*t); % a complex sequence tested.
X=fft(x,N)/N;% fast frourier transform
X=fftshift(X);
Y=fliplr(X); %X(e^-jw)
Y_conj=conj(Y);
f=[-N/2:N/2-1]*fs/N; % frequency sequence;
```

2.1 Property 1

For Proving the property 1, we can get the Figure 3, which can prove the correction of it. The figure is generated by the following programs. In the first row, their magnitude are shown which are the same; in the second row, their phases are shown which are the same.

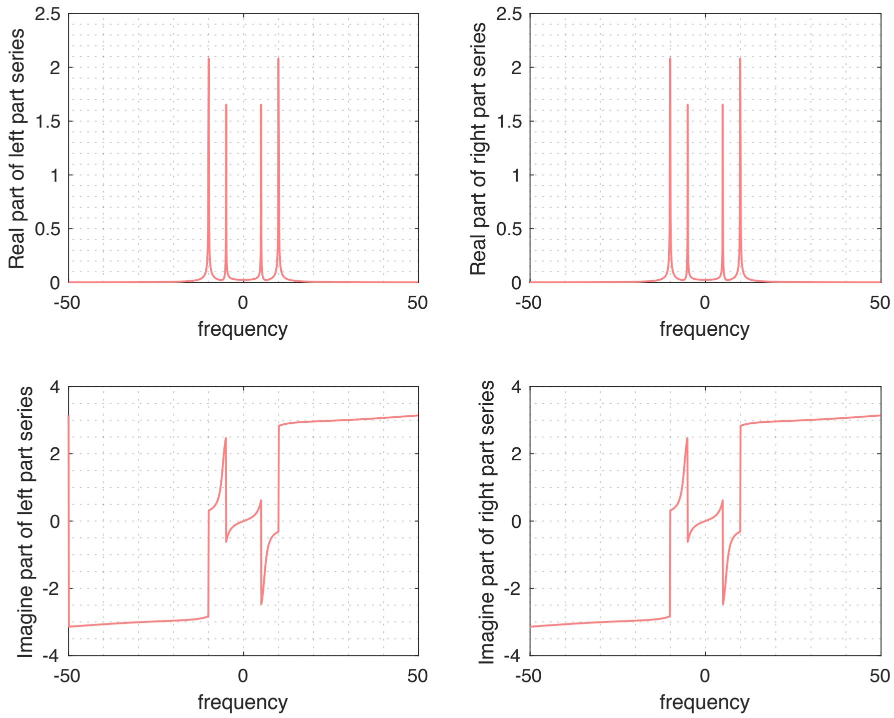

Figure 3: Property 1

```
% figure 1
figure(1);
subplot(2,2,1);plot(f,abs(X),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Real part of left part series')
subplot(2,2,2);plot(f,abs(Y_conj),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Real part of right part series')
subplot(2,2,3);plot(f,angle(X),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Imagine part of left part ...
    series')
subplot(2,2,4);plot(f,angle(Y_conj),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Imagine part of right part ...
    series')
```

2.2 Property 2 and 3

For Proving the property 2 and 3, we can get the Figure 4, which can prove the correction of it. The figure is generated by the following programs. The first row shows that their real part is the same; the second row shows that their image parts are inverse.

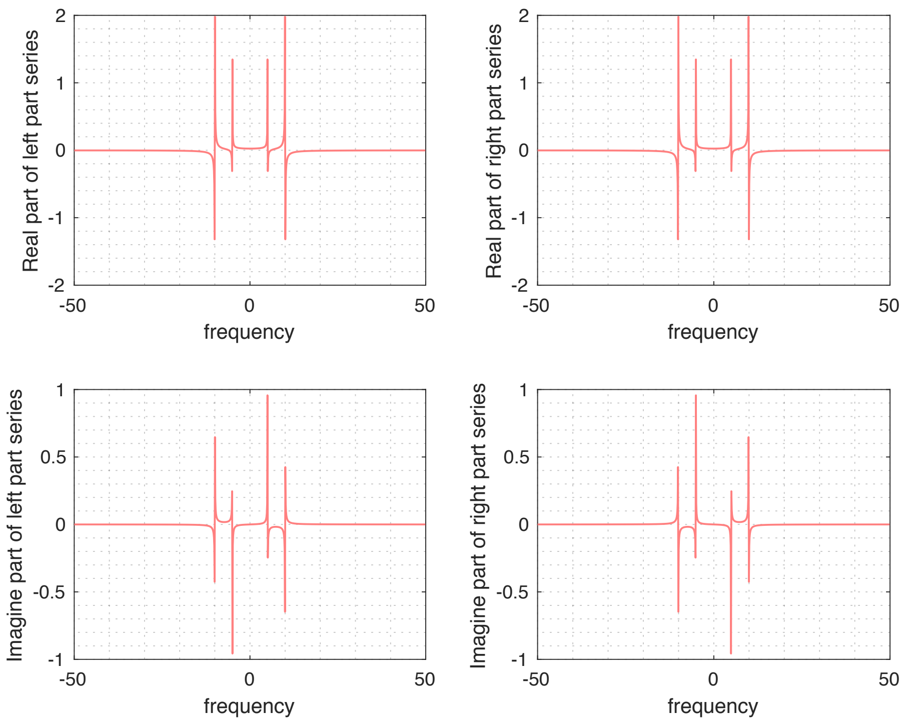

Figure 4: Property 2 and 3

```
% figure 2
figure(2);
subplot(2,2,1);plot(f,real(X),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Real part of left part series')
subplot(2,2,2);plot(f,real(Y),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Real part of right part series')
subplot(2,2,3);plot(f,imag(X),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Imagine part of left part ...
    series')
subplot(2,2,4);plot(f,imag(Y),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Imagine part of right part ...
    series')
```

2.3 Property 4 and 5

For Proving the property 4 and 5, we can get the Figure 5, which can prove the correction of it. The figure is generated by the following programs.The property 4 is proved in the first row as the absolute value are the same; the property 5 is proved in the second row as their angle is inverse.

```
% figure 3
```

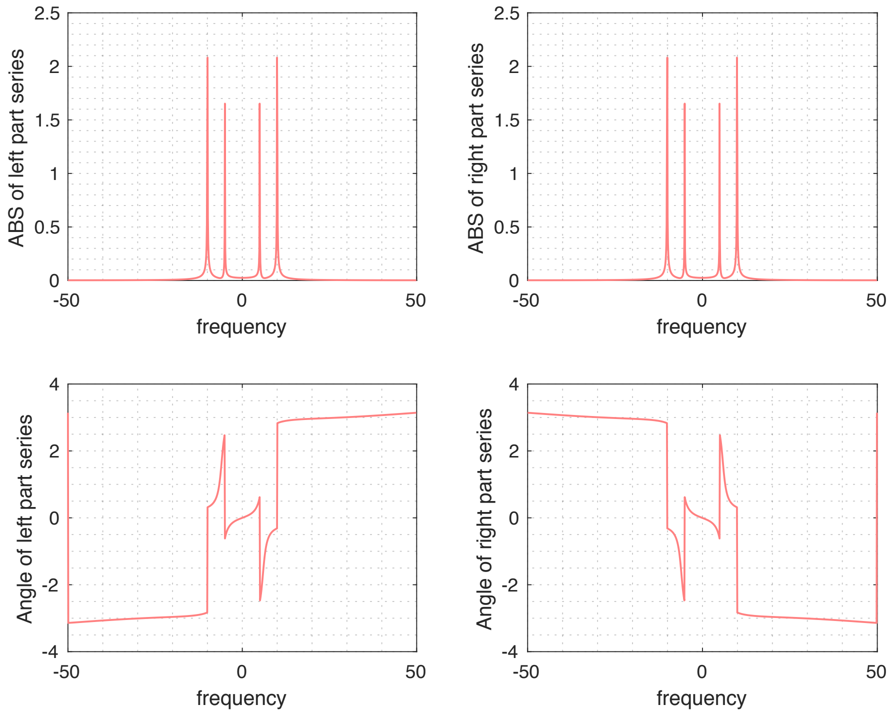

Figure 5: Property 4 and 5

```
x_real=real(x); %x_real[n]
X_real=fftshift(fft(x_real,N))*2/N;
X_cs=0.5*(X+conj(fliplr(X)));
figure(3);
subplot(2,2,1);plot(f,abs(X),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('ABS of left part series')
subplot(2,2,2);plot(f,abs(Y),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('ABS of right part series')
subplot(2,2,3);plot(f,angle(X),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Angle of left part series')
subplot(2,2,4);plot(f,angle(Y),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Angle of right part series')
```

3 PROBLEM M3.5

Using the matlab to verify the symmetry relations of DTFT of a complex sequence as listed in Table 3-2:

For solving this question, I first define a complex sequence as shown in the following programs. The function is shown as follows: $x = 0.7e^{5i\pi t + t^2}$

Note that the tested sequence can be modified which would not influence the final conclusion.

```
% Author: Changgang Zheng
% UESTC ID: 2016200302027
% UoG ID: 2289258z
clear;
clc;

fs=100; % sampling frequency;
N=1024;% sampling points number;
n=[0:N-1]; %order sequence;
t=n/fs; % time sequence;
x=0.7*exp(1i*5*pi*t+t.*t); % a complex sequence tested.
X=fft(x,N)*2/N;% fast frourier transform
X=fftshift(X);
f=[-N/2:N/2-1]*fs/N; % frequency sequence;
```

3.1 Property 1

For Proving the property 1, we can get the Figure 6. The real and imaginary parts are both very similar, which can prove the correction of it. The figure is generated by the following programs.

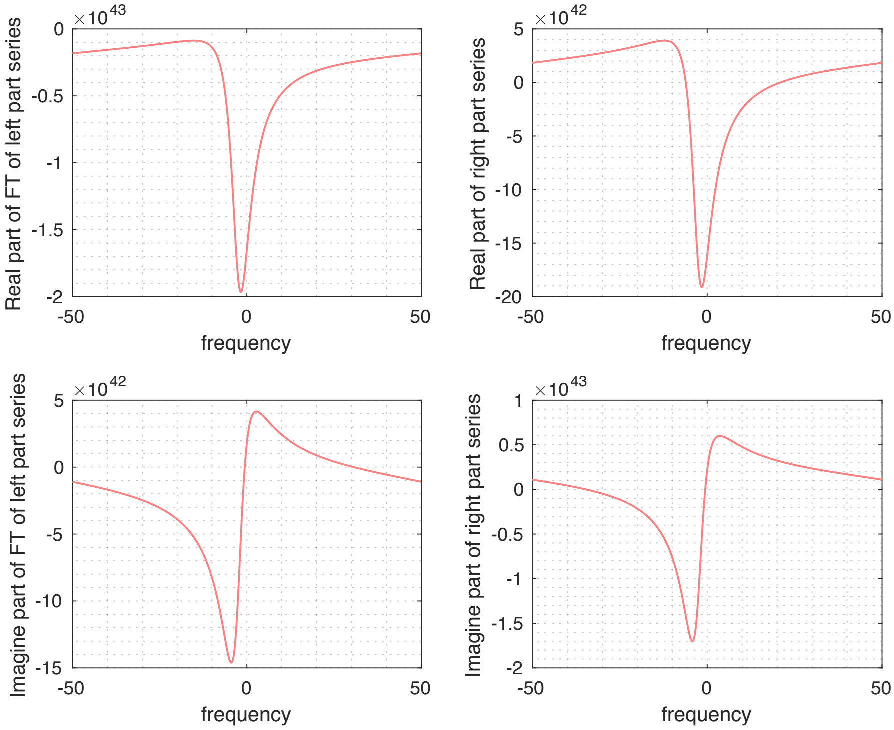

Figure 6: Property 1

```
% property 1
x_inverse=fliplr(x); % x[-n]
X_inverse=fftshift(fft(x_inverse,N))*2/N;
figure(1);
```

```
subplot(2,2,1);plot(f,real(X_inverse),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Real part of FT of left part ...
    series')
subplot(2,2,2);plot(f,real(fliplr(X)),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Real part of right part series')
subplot(2,2,3);plot(f,imag(X_inverse),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Imagine part of FT of left ...
    part series')
subplot(2,2,4);plot(f,imag(fliplr(X)),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Imagine part of right part ...
    series')
```

3.2 Property 2

For Proving the property 2, we can get the Figure 7. The real and imaginary parts are both very similar, which can prove the correction of it. The figure is generated by the following programs.

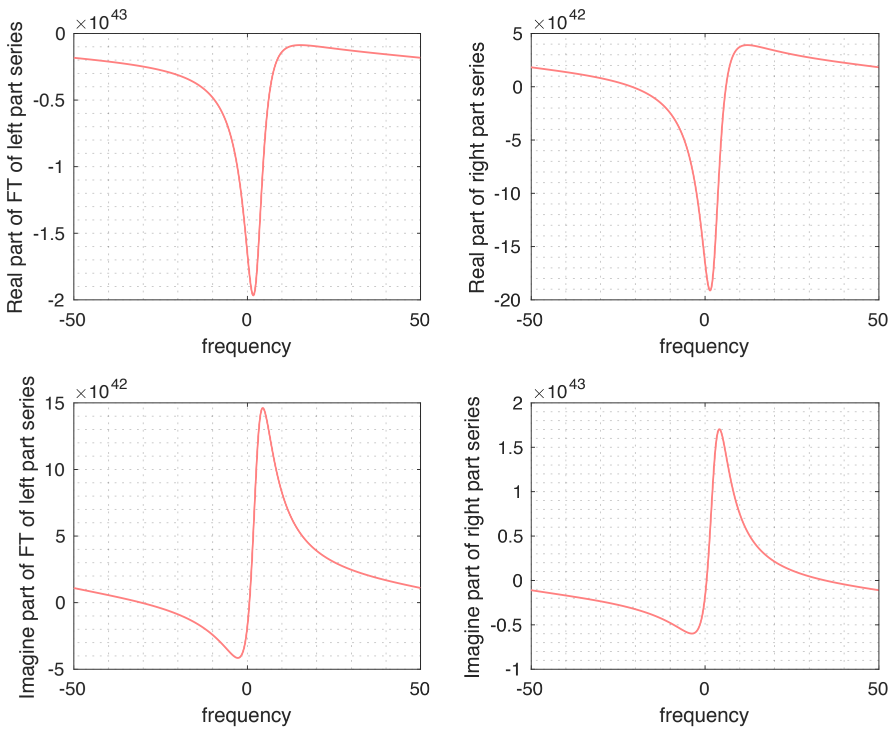

Figure 7: Property 2

```
% property 2
x_inverse_conj=conj(x_inverse); % x*[-n]
X_inverse_conj=fftshift(fft(x_inverse_conj,N))*2/N;
figure(2);
subplot(2,2,1);plot(f,real(X_inverse_conj),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Real part of FT of left part ...
    series')
```

```
subplot(2,2,2);plot(f,real(conj(X)),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Real part of right part series')
subplot(2,2,3);plot(f,imag(X_inverse_conj),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Imagine part of FT of left ...
    part series')
subplot(2,2,4);plot(f,imag(conj(X)),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Imagine part of right part ...
    series')
```

3.3 Property 3

For Proving the property 3, we can get the Figure 8. The magnitude and phase parts are both very similar, which can prove the correction of it. The figure is generated by the following programs.

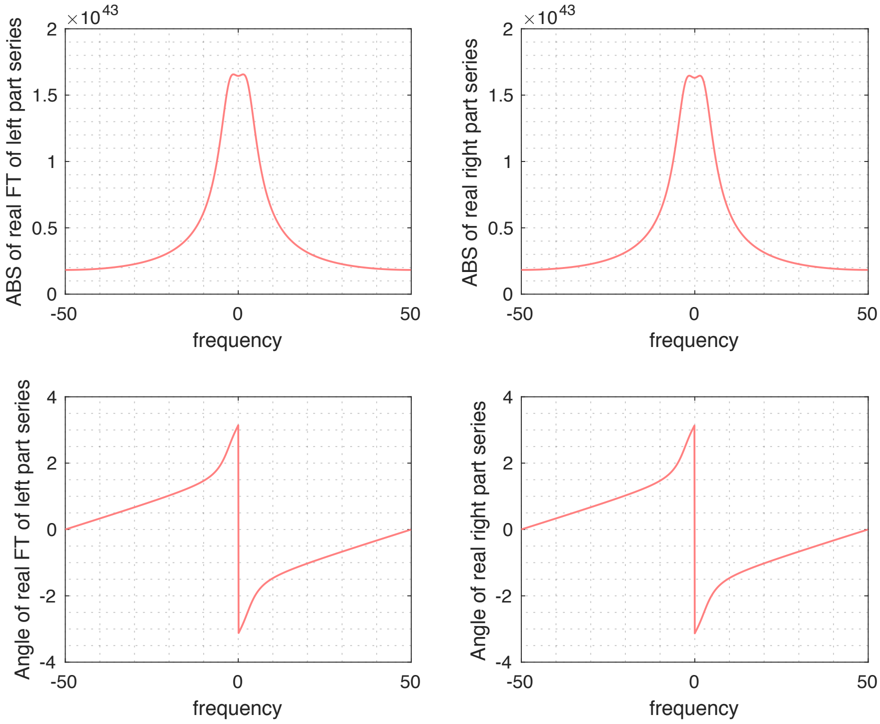

Figure 8: Property 3

```
% property 3
x_real=real(x); %x_real[n]
X_real=fftshift(fft(x_real,N))*2/N;
X_cs=0.5*(X+conj(fliplr(X)));
figure(3);
subplot(2,2,1);plot(f,abs(X_real),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('ABS of real FT of left part ...
    series')
subplot(2,2,2);plot(f,abs(X_cs),'LineWidth',1,'color',[1,0.5,0.5]);
```

```
grid minor;xlabel('frequency');ylabel('ABS of real right part series')
subplot(2,2,3);plot(f,angle(X_real),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Angle of real FT of left ...
    part series')
subplot(2,2,4);plot(f,angle(X_cs),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Angle of real right part ...
    series')
```

3.4 Property 4

For Proving the property 4, we can get the Figure 9. The magnitude and phase parts are both very similar, which can prove the correction of it. The figure is generated by the following programs.

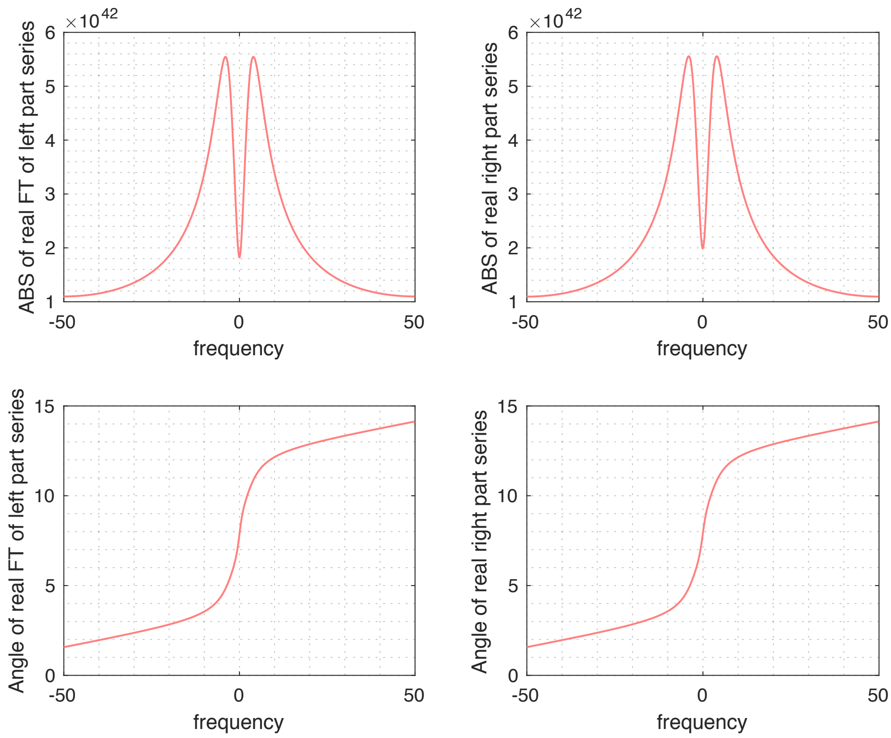

Figure 9: Property 4

```
% property 4
x_imag=1i*imag(x); %i*x_image[n]
X_imag=fftshift(fft(x_imag,N))*2/N;
X_ca=0.5*(X-conj(fliplr(X)));
figure(4);
subplot(2,2,1);plot(f,abs(X_imag),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('ABS of real FT of left part ...
    series')
subplot(2,2,2);plot(f,abs(X_ca),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('ABS of real right part series')
```

```
subplot(2,2,3);plot(f,unwrap(angle(X_imag)),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Angle of real FT of left ...
    part series')
subplot(2,2,4);plot(f,unwrap(angle(X_ca)),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Angle of real right part ...
    series')
```

3.5 Property 5

For Proving the property 5, we can get the Figure 10. The fourier transform of the conjugate symmetric is same as the real part of the fourier transform of the original sequence, which can prove the correction of it. The figure is generated by the following programs.

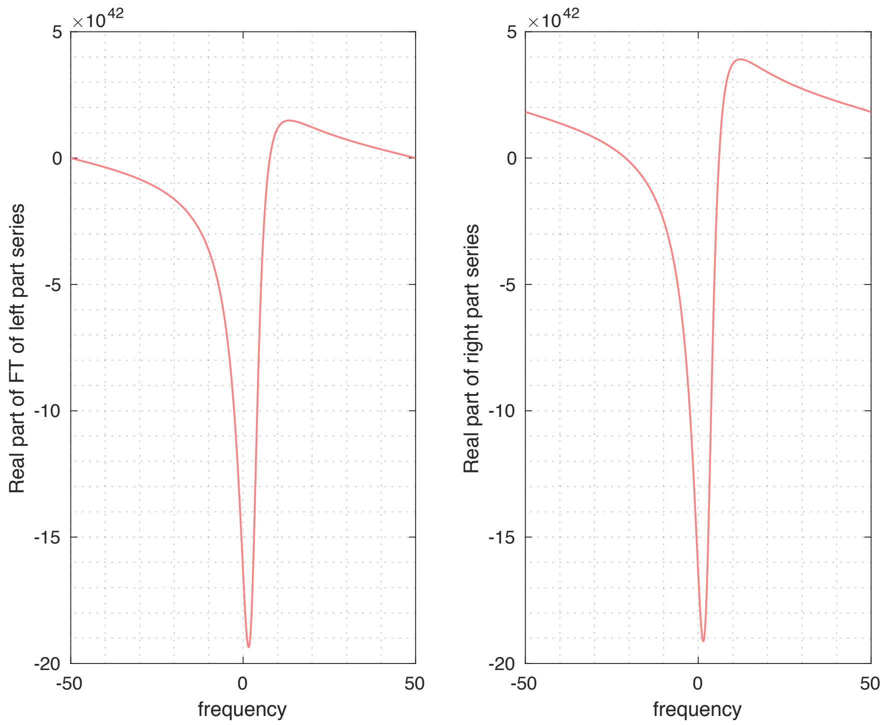

Figure 10: Property 5

```
% property 5
x_cs=0.5*(x+conj(fliplr(x))); %x_cs[n]
X_cs=fftshift(fft(x_cs,N))*2/N;
figure(5);
subplot(1,2,1);plot(f,real(X_cs),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Real part of FT of left part ...
    series')
subplot(1,2,2);plot(f,real(X),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Real part of right part series')
```

3.6 Property 6

For Proving the property 6, we can get the Figure 11. The fourier transform of the conjugate antisymmetric is same as the j multiply imaginary part of the fourier transform of the original sequence, which can prove the correction of it. The figure is generated by the following programs.

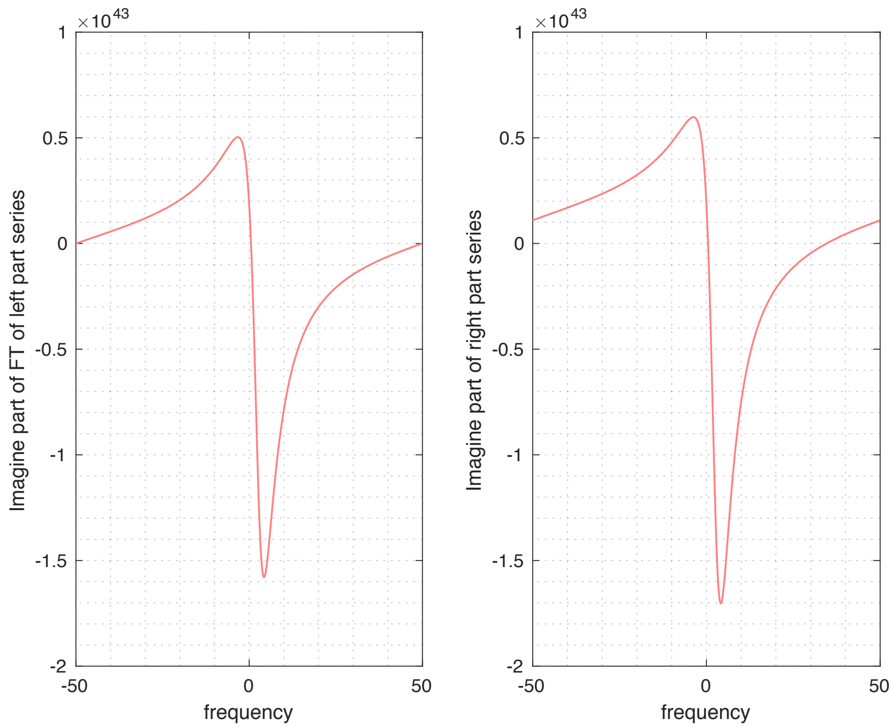

Figure 11: Property 6

```
% property 6
x_ca=0.5*(x-conj(fliplr(x))); %x_ca[n]
X_ca=fftshift(fft(x_ca,N))*2/N;
figure(6);
subplot(1,2,1);plot(f,imag(X_ca),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Imagine part of FT of left ...
    part series')
subplot(1,2,2);plot(f,imag(X),'LineWidth',1,'color',[1,0.5,0.5]);
grid minor;xlabel('frequency');ylabel('Imagine part of right part ...
    series')
```

4 SUMMARY

For this Homework, I understand more about Digital Signal Processing, as well as how to use the MATLAB to plot and analysis series about DTFT. I also know more about the property of the DTFT for both real and complex signals, as well as how to prove them.

REFERENCES

[1] Changgang-Zheng/Signals-and-Systems/report.https://github.com/Changgang-Zheng/Signals-and-Systems

[2] Supplementary materials to the text book 'Digital Signal Processing: A Computer-Based Approach', 4th Edition. by S.K. Mitra, ISBN 0077320670. http://www.bb9.uestc.edu.cn/webapps/portal/frameset.jsp?tab_tab_group_id=_2_1&url=%2Fwebapps%2Fblackboard%2Fexecute%2Flauncher%3Ftype%3DCourse%26id%3D_13014_1%26url%3D

[3] Digital Signal Processing: A Computer-Based Approach, 4th Edition. by S.K. Mitra, ISBN 0077320670.