

Glasgow College, UESTC



Digital Signal Processing

Homework 4

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University
of Glasgow



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University of Electronic Science and Technology of China

HOMWORK 4

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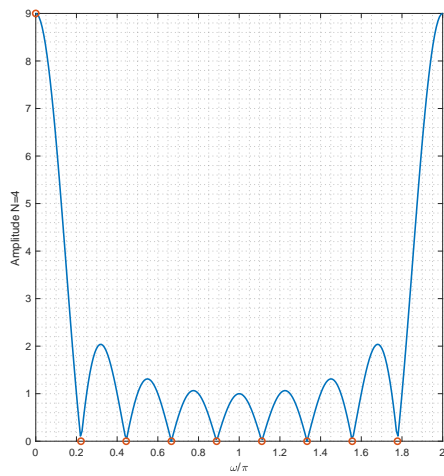
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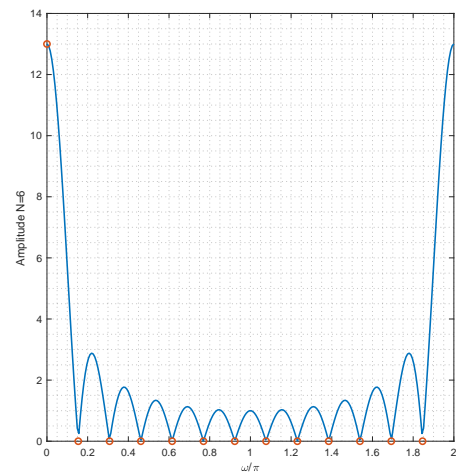
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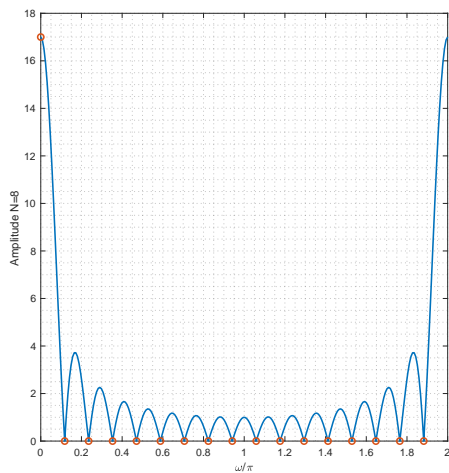
1 PROBLEM 5.1



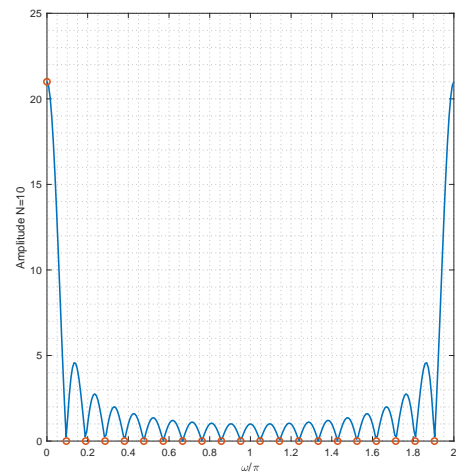
N=4



N=6

Figure 1: DFT and DTFT of $y_1[n]$ 

N=8



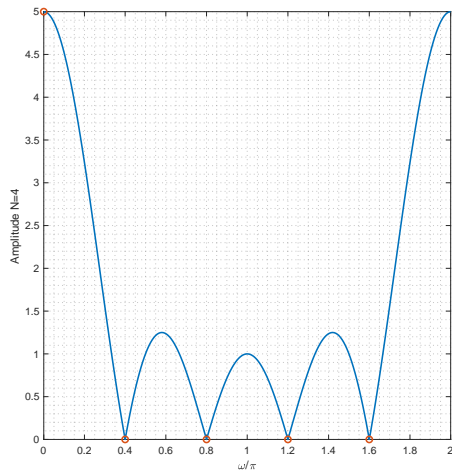
N=10

Figure 2: DFT and DTFT of $y_1[n]$

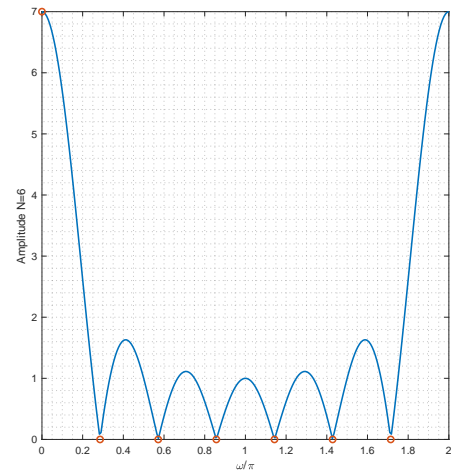
```

1 clear
2 clc
3 for N=[4 6 8 10]
4     %% Program M5.1 (a)
5     % N = input('The value of N = ');

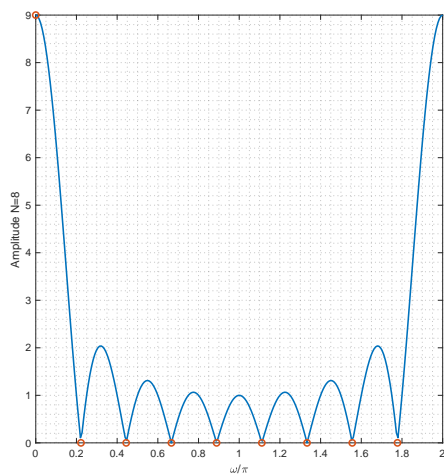
```



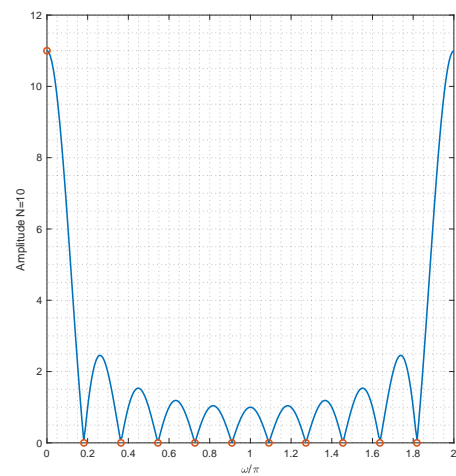
N=4



N=6

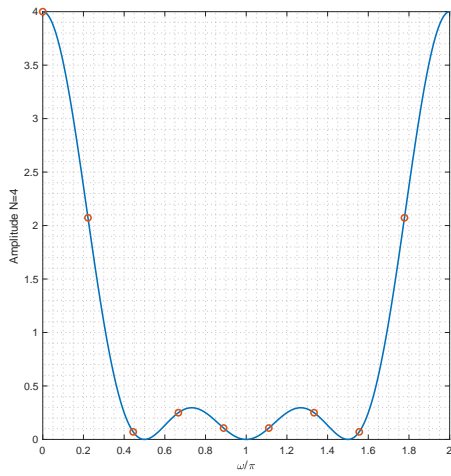
Figure 3: DFT and DTFT of $y_2[n]$ 

N=8

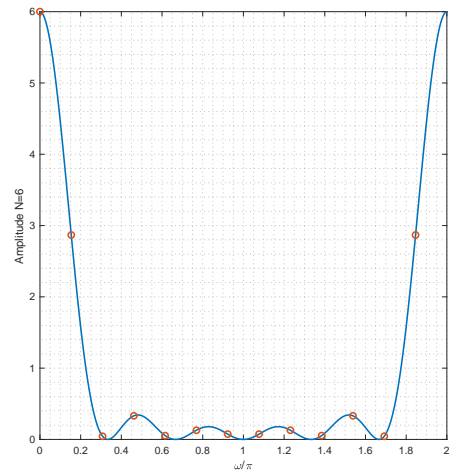


N=10

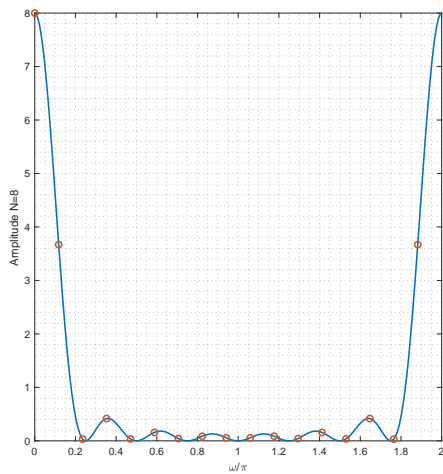
Figure 4: DFT and DTFT of $y_2[n]$



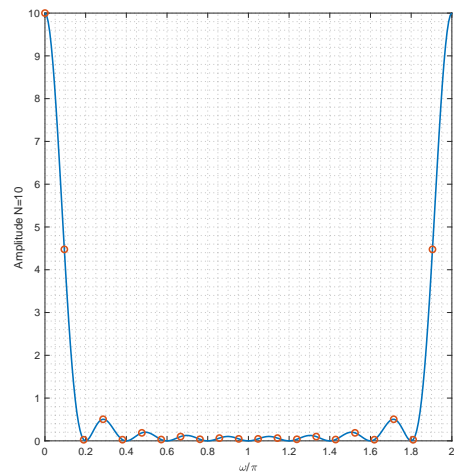
N=4



N=6

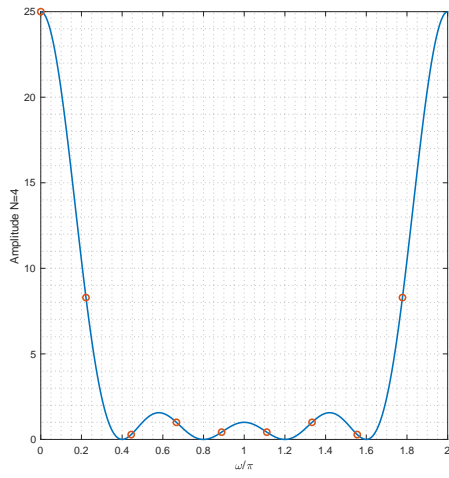
Figure 5: DFT and DTFT of $y_3[n]$ 

N=8

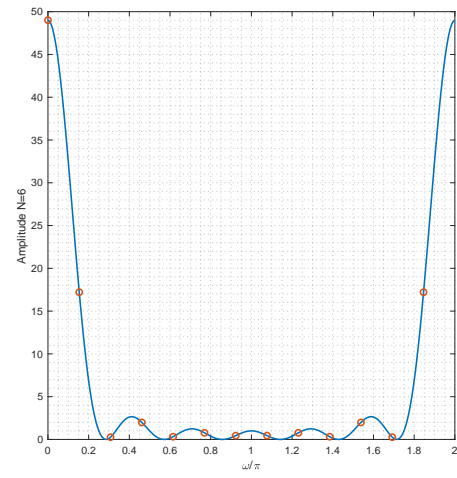


N=10

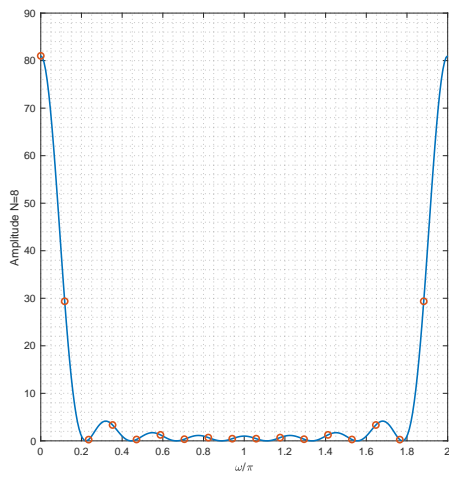
Figure 6: DFT and DTFT of $y_3[n]$



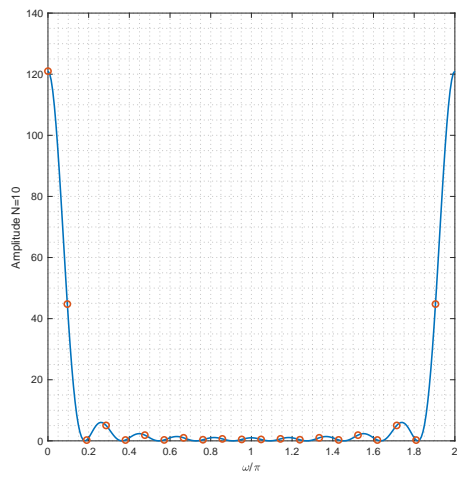
N=4



N=6

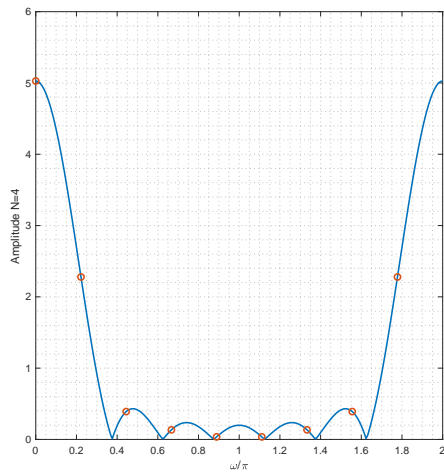
Figure 7: DFT and DTFT of $y_4[n]$ 

N=8

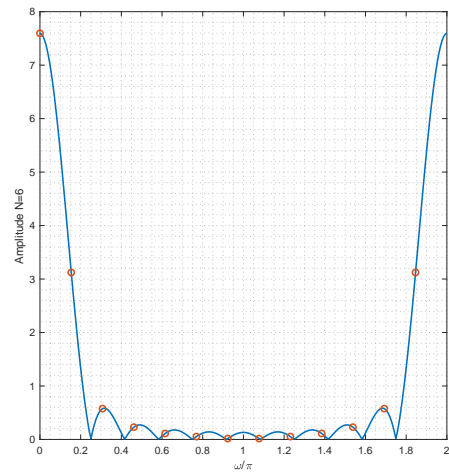


N=10

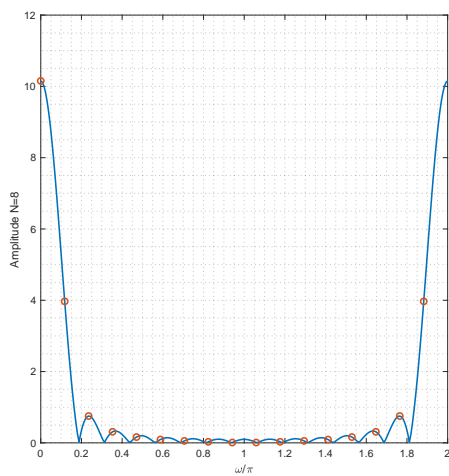
Figure 8: DFT and DTFT of $y_4[n]$



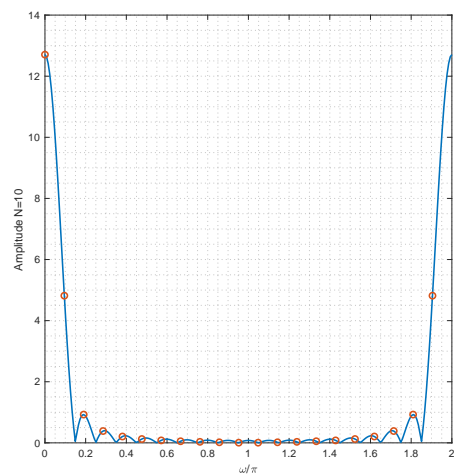
N=4



N=6

Figure 9: DFT and DTFT of $y_5[n]$ 

N=8



N=10

Figure 10: DFT and DTFT of $y_5[n]$

```

6   k = -N:N;
7   y = ones(1,2*N+1);
8   w = 0:2*pi/255:2*pi;
9   Y = freqz(y, 1, w);
10  Ydft = fft(y);
11  n = 0:1:2*N;
12  sequence_a = figure;
13  plot(w/pi,abs(Y),'LineWidth',1.5)
14  hold on
15  plot(n*2/(2*N+1),abs(Ydft),'o','LineWidth',1.5);
16  xlabel('\omega/\pi');
17  ylabel(['Amplitude N=',num2str(N)]);
18  grid minor
19  set(sequence_a, 'PaperPosition', [0.05 0.05 7 7]);
20  set(sequence_a, 'PaperSize', [7.05 7.05]); %Keep the same paper size
21  saveas(sequence_a,['sequence_a',num2str(N),'.pdf'],'pdf')
22  %% Program M5.1 (b)
23  % N = input('The value of N = ');
24  k = 0:N;
25  y = ones(1,N+1);
26  w = 0:2*pi/255:2*pi;
27  Y = freqz(y, 1, w);
28  Ydft = fft(y);
29  sequence_b = figure;
30  n = 0:N;
31  plot(w/pi,abs(Y),n*2/(N+1),abs(Ydft),'o','LineWidth',1.5);
32  xlabel('\omega/\pi');
33  ylabel(['Amplitude N=',num2str(N)]);
34  grid minor
35  set(sequence_b, 'PaperPosition', [0.05 0.05 7 7]);
36  set(sequence_b, 'PaperSize', [7.05 7.05]); %Keep the same paper size
37  saveas(sequence_b,['sequence_b',num2str(N),'.pdf'],'pdf')
38  %% Program M5.1 (c)
39  % N = input('The value of N = ');
40  k = -N:N;
41  y = ones(1,2*N+1);
42  y = y - abs(k)/N;
43  w = 0:2*pi/255:2*pi;
44  Y = freqz(y, 1, w);
45  Ydft = fft(y);
46  sequence_c = figure;
47  n = 0:1:2*N;
48  plot(w/pi,abs(Y),n*2/(2*N+1),abs(Ydft),'o','LineWidth',1.5);
49  xlabel('\omega/\pi');
50  ylabel(['Amplitude N=',num2str(N)]);
51  grid minor
52  set(sequence_c, 'PaperPosition', [0.05 0.05 7 7]);
53  set(sequence_c, 'PaperSize', [7.05 7.05]); %Keep the same paper size
54  saveas(sequence_c,['sequence_c',num2str(N),'.pdf'],'pdf')
55  %% Program M5.1 (d)
56  % N = input('The value of N = ');
57  k = -N:N;
58  y = N + ones(1,2*N+1) - abs(k);

```



```

59 w = 0:2*pi/255:2*pi;
60 Y = freqz(y, 1, w);
61 Ydft = fft(y);
62 sequence_d = figure;
63 n = 0:1:2*N;
64 plot(w/pi,abs(Y),n*2/(2*N+1),abs(Ydft),'o','LineWidth',1.5);
65 xlabel('\omega/\pi');
66 ylabel(['Amplitude N=',num2str(N)]);
67 grid minor
68 set(sequence_d, 'PaperPosition', [0.05 0.05 7 7]);
69 set(sequence_d, 'PaperSize', [7.05 7.05]); %Keep the same paper size
70 saveas(sequence_d, ['sequence_d',num2str(N),'.pdf'],'pdf')
71 %% Program M5.1 (e)
72 % N = input('The value of N = ');
73 k = -N:N;
74 y = cos(pi*k/(2*N));
75 w = 0:2*pi/255:2*pi;
76 Y = freqz(y, 1, w);
77 Ydft = fft(y);
78 n = 0:1:2*N;
79 sequence_e = figure;
80 plot(w/pi,abs(Y),n*2/(2*N+1),abs(Ydft),'o','LineWidth',1.5);
81 xlabel('\omega/\pi');
82 ylabel(['Amplitude N=',num2str(N)]);
83 grid minor
84 set(sequence_e, 'PaperPosition', [0.05 0.05 7 7]);
85 set(sequence_e, 'PaperSize', [7.05 7.05]); %Keep the same paper size
86 saveas(sequence_e, ['sequence_e',num2str(N),'.pdf'],'pdf')
87 end

```

2 PROBLEM 5.3

```

1 N = 8; % sequence length
2 gamma = 0.5;
3 k = 0:N-1;
4 x = exp(-gamma*k);
5 X = fft(x);
6 range = k;
7 %% Property 1
8 X1 = fft(conj(x));
9 G1 = conj([X(1) X(N:-1:2)]);
10
11 % Verify X1 = G1
12
13 p1_1=figure;
14 stem(range,real(X1),'.','LineWidth',2,'color',[1,0.5,0.5]);
15 hold on;
16 stem(range,imag(X1),'.','LineWidth',1.5,'color',[0.5,0.5,1]);

```

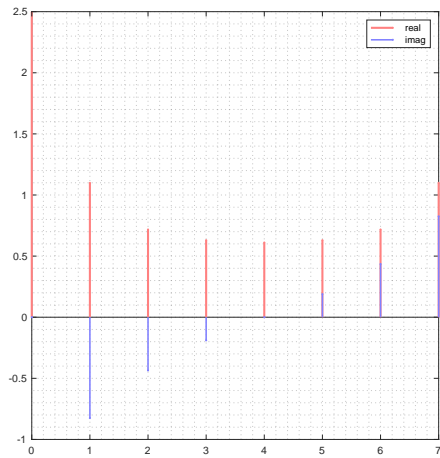
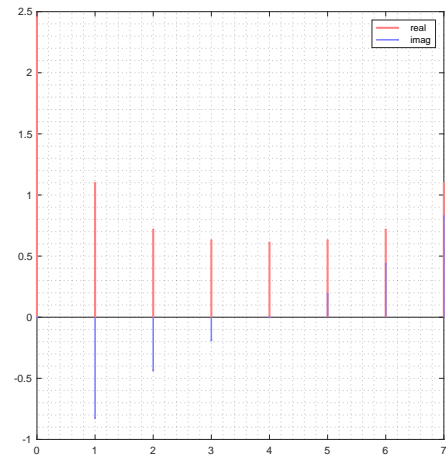
 $X^*[n]$ real part $X^*[-k]$ real part

Figure 11: Property 1

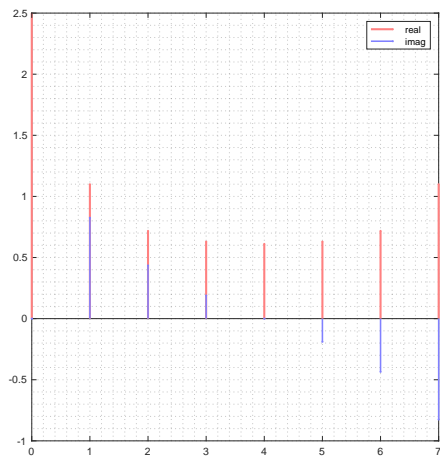
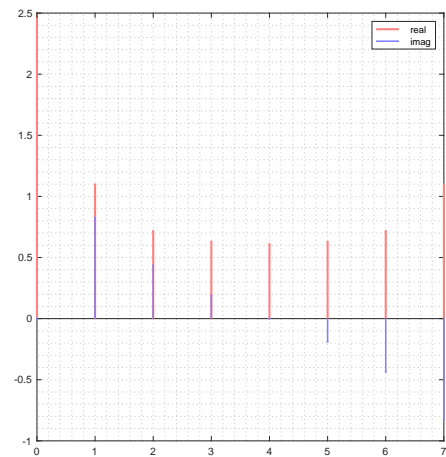
 $X^*[k]$ real part $X^*[\langle k \rangle_N]$ real part

Figure 12: Property 2

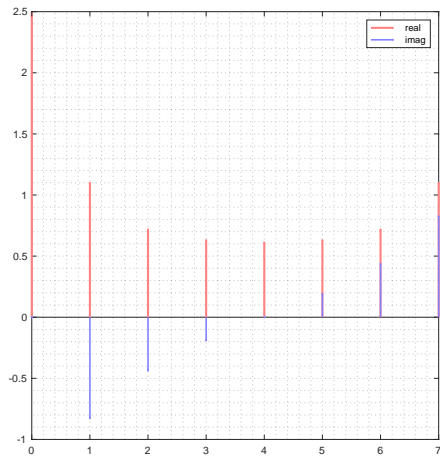
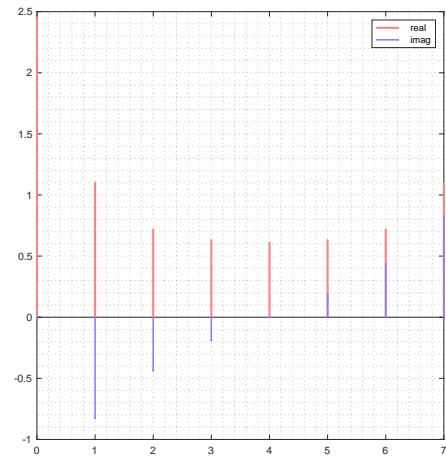
 $X_{re}[k]$ real part $X_{cs}[k]$ real part

Figure 13: Property 3

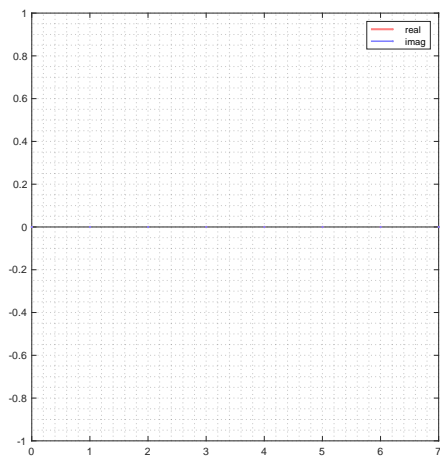
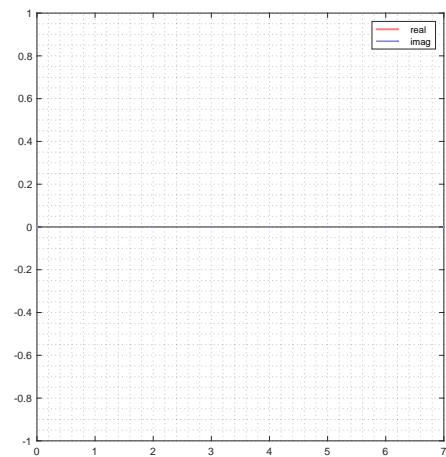
 $jX_{im}[k]$ imag part $X_{ca}[k]$ imag part

Figure 14: Property 4

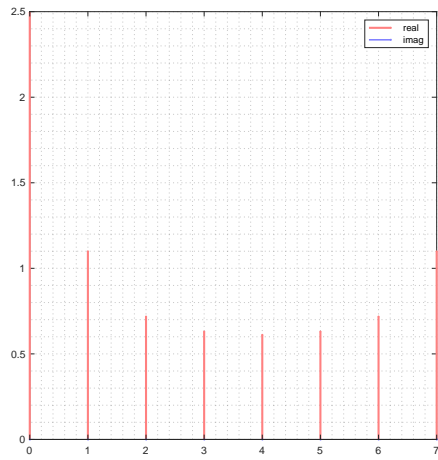
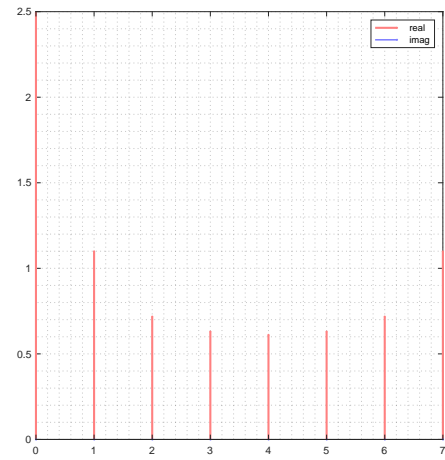
 $X_{cs}[k]$ real part $X_{re}[k]$ real part

Figure 15: Property 5

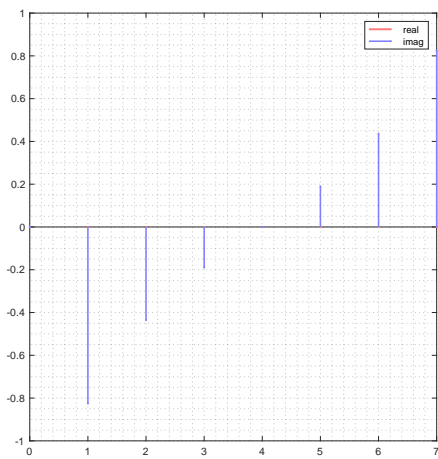
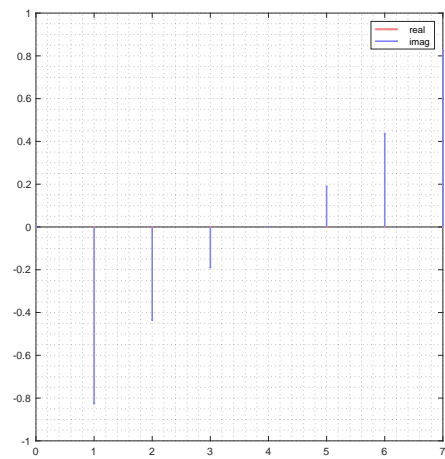
 $X_{ca}[k]$ real part $X_{ca}[k]$ real part

Figure 16: Property 6

```

17 grid minor
18 legend('real','imag')
19 set(p1_1, 'PaperPosition', [0.05 0.05 7 7]);
20 set(p1_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
21 saveas(p1_1, ['p1_1.pdf'], 'pdf')
22
23 p1_2=figure;
24 stem(range,real(G1),'.','LineWidth',2,'color',[1,0.5,0.5]);
25 hold on;
26 stem(range,imag(G1),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
27 legend('real','imag')
28 grid minor
29 set(p1_2, 'PaperPosition', [0.05 0.05 7 7]);
30 set(p1_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
31 saveas(p1_2, ['p1_2.pdf'], 'pdf')
32 %% Property 2
33 x2 = conj([x(1) x(N:-1:2)]);
34 X2 = fft(x2);
35 % Verify X2 = conj(X)
36 p2_1=figure;
37 stem(range,real(X2),'.','LineWidth',2,'color',[1,0.5,0.5]);
38 hold on;
39 stem(range,imag(X2),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
40 legend('real','imag')
41 grid minor
42 set(p2_1, 'PaperPosition', [0.05 0.05 7 7]);
43 set(p2_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
44 saveas(p2_1, ['p2_1.pdf'], 'pdf')
45
46 p2_2=figure;
47 stem(range,real(conj(X)),'.','LineWidth',2,'color',[1,0.5,0.5]);
48 hold on;
49 stem(range,imag(conj(X)),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
50 legend('real','imag')
51 grid minor
52 set(p2_2, 'PaperPosition', [0.05 0.05 7 7]);
53 set(p2_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
54 saveas(p2_2, ['p2_2.pdf'], 'pdf')
55 %% Property 3
56 x3 = real(x);
57 X3 = fft(x3);
58 G3 = 0.5*(X+conj([X(1) X(N:-1:2)]));
59
60 % Verify X3 = G3
61 p3_1=figure;
62 stem(range,real(X3),'.','LineWidth',2,'color',[1,0.5,0.5]);
63 hold on;
64 stem(range,imag(X3),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
65 legend('real','imag')
66 grid minor
67 set(p3_1, 'PaperPosition', [0.05 0.05 7 7]);
68 set(p3_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
69 saveas(p3_1, ['p3_1.pdf'], 'pdf')

```

```

70
71 p3_2=figure;
72 stem(range,real(G3),'.','LineWidth',2,'color',[1,0.5,0.5]);
73 hold on;
74 stem(range,imag(G3),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
75 legend('real','imag')
76 grid minor
77 set(p3_2, 'PaperPosition', [0.05 0.05 7 7]);
78 set(p3_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
79 saveas(p3_2,['p3_2.pdf'],'pdf')
80 %% Property 4
81 x4 = j*imag(x);
82 X4 = fft(x4);
83 G4 = 0.5*(X-conj([X(1) X(N:-1:2)]));
84 % Verify X4 = G4
85 p4_1=figure;
86 stem(range,real(X4),'.','LineWidth',2,'color',[1,0.5,0.5]);
87 hold on;
88 stem(range,imag(X4),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
89 legend('real','imag')
90 grid minor
91 set(p4_1, 'PaperPosition', [0.05 0.05 7 7]);
92 set(p4_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
93 saveas(p4_1,['p4_1.pdf'],'pdf')
94
95 p4_2=figure;
96 stem(range,real(G4),'.','LineWidth',2,'color',[1,0.5,0.5]);
97 hold on;
98 stem(range,imag(G4),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
99 legend('real','imag')
100 grid minor
101 set(p4_2, 'PaperPosition', [0.05 0.05 7 7]);
102 set(p4_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
103 saveas(p4_2,['p4_2.pdf'],'pdf')
104 %% Property 5
105 x5 = 0.5*(x+conj([x(1) x(N:-1:2)]));
106 X5 = fft(x5);
107 % Verify X5 = real(X)
108 p5_1=figure;
109 stem(range,real(X5),'.','LineWidth',2,'color',[1,0.5,0.5]);
110 hold on;
111 stem(range,imag(X5),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
112 legend('real','imag')
113 grid minor
114 set(p5_1, 'PaperPosition', [0.05 0.05 7 7]);
115 set(p5_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
116 saveas(p5_1,['p5_1.pdf'],'pdf')
117
118 p5_2=figure;
119 stem(range,real(real(X)),'.','LineWidth',2,'color',[1,0.5,0.5]);
120 hold on;
121 stem(range,imag(real(X)),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
122 legend('real','imag')

```

```

123 grid minor
124 set(p5_2, 'PaperPosition', [0.05 0.05 7 7]);
125 set(p5_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
126 saveas(p5_2, ['p5_2.pdf'], 'pdf')
127 %% Property 6
128 x6 = 0.5*(x-conj([x(1) x(N:-1:2)]));
129 X6 = fft(x6);
130 % Verify X6 = j*imag(X)
131 p6_1=figure;
132 stem(range,real(X6),'.','LineWidth',2,'color',[1,0.5,0.5]);
133 hold on;
134 stem(range,imag(X6),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
135 legend('real','imag')
136 grid minor
137 set(p6_1, 'PaperPosition', [0.05 0.05 7 7]);
138 set(p6_1, 'PaperSize', [7.05 7.05]); %Keep the same paper size
139 saveas(p6_1, ['p6_1.pdf'], 'pdf')
140 p6_2=figure;
141 stem(range,real(1j*imag(X)),'.','LineWidth',2,'color',[1,0.5,0.5]);
142 hold on;
143 stem(range,imag(1j*imag(X)),'.','LineWidth',1.5,'color',[0.5,0.5,1]);
144 legend('real','imag')
145 grid minor
146 set(p6_2, 'PaperPosition', [0.05 0.05 7 7]);
147 set(p6_2, 'PaperSize', [7.05 7.05]); %Keep the same paper size
148 saveas(p6_2, ['p6_2.pdf'], 'pdf')

```

3 PROBLEM 5.8

I got the output:

```

1 >> problem_5_8
2      6.4400 + 0.0000i -30.6600 + 0.0000i  62.9000 + 0.0000i -91.5000 ...
      - 0.0000i
3
4      4.9134e+03

```

From the following program:

```

1 x = [6.29 8.11 -7.46 8.26 2.64 -8.04 -4.43 0.93 -9.15 9.29];
2 XF = fft(x);
3 k =0:9;
4 YF = exp(-i*2*pi*k/5).*XF;
5 output = [XF(1) XF(6) sum(XF) sum(YF)];
6 disp(output)
7 disp(sum(abs(XF).*abs(XF)))

```

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 and how to smooth the signals. I also understand what will be the effect if we use the filter to smooth the signal. I also know more about the property of the filter and how to generate the system to help us impliment some operation like square root.

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.