数字信号处理B

PB21511897 李霄奕

HW4

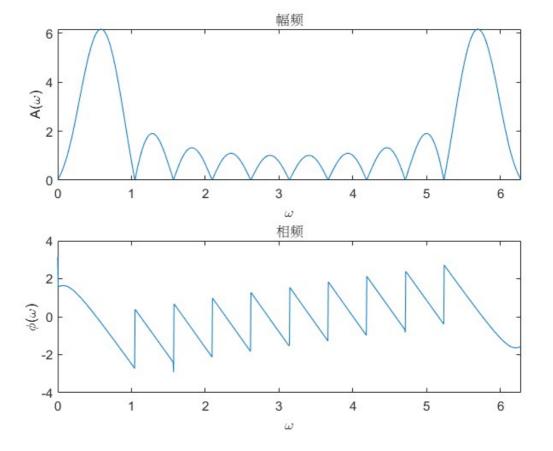
Exercise 1

$$x(n) = \cos(n\pi/6), \quad n = 0...12$$

(1)

源代码:

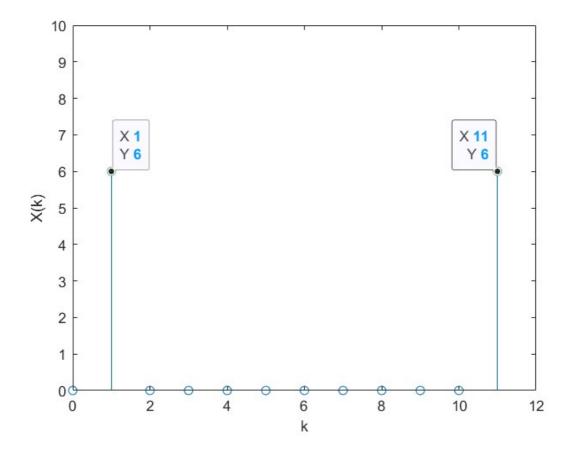
```
N_1=12;
    N_2=1000;
 3
    step_1=1:N_1;
 4
    step_2=1:N_2;
 5
   n=step_1-1;
 6
   x=cos(n.*pi/6);
 7
    w=(step_2-1)./N_2.*2.*pi;
 8
    for step_1=1:N_1
9
        for step_2=1:N_2
10
            A(step_1, step_2) = x(step_1).*exp(-i.*w(step_2).*n(step_1));
11
        end
12
    end
13
    step_1=1:N_1;
14
    step_2=1:N_2;
15
    X(step_2)=sum(A(:,step_2));
16
    subplot(2,1,1);
17
    plot(w,abs(X));
18
    xlim([0,2*pi]);
19
    title('幅频');
20
    xlabel('\omega');
21
    ylabel('A(\omega)');
    hold on;
22
23
    subplot(2,1,2);
24
    plot(w,angle(X));
25
    xlim([0,2*pi]);
26
    title('相频');
27
    xlabel('\omega');
    ylabel('\phi(\omega)');
28
29
    hold off;
```



(2)

源代码:

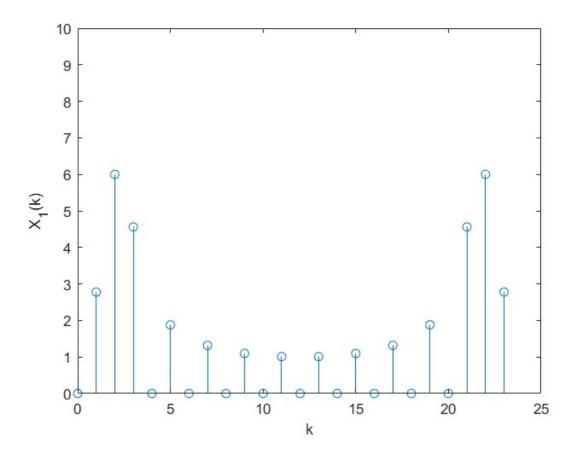
```
1
   N_1=12;
2
   step_1=1:N_1;
3
   n=step_1-1;
4
   x=cos(n.*pi/6);
5
   X=fft(x);
6
   stem(n,abs(X));
7
   ylim([0,10]);
   xlabel('k');
8
   ylabel('x(k)');
```



(3)

源代码:

```
1
    N_1=12;
2
    step_1=1:N_1;
 3
    n=step_1-1;
    x=cos(n.*pi/6);
5
    x_1=[x,zeros(1,N_1)];
 6
    X_1=fft(x_1);
7
    stem([0:2*N_1-1],abs(X_1));
8
    ylim([0,10]);
9
    xlabel('k');
    ylabel('X_1(k)');
10
```



结论:

对于DFT与DTFT之间的关系, DFT是对DTFT的采样。

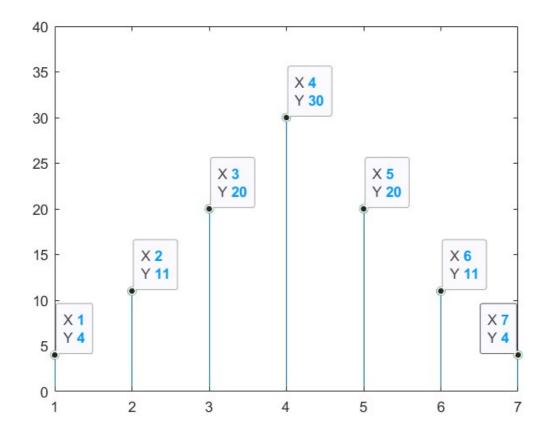
对于正弦信号抽样,抽样序列后面补零,所取的点越密集,DFT与DTFT越接近。

Exercise 2

(1)

源代码:

```
1 | x=[1,2,3,4];
2 | h=[4,3,2,1];
3 | y=conv(x,h);
```



(2)

源代码:

```
1 x=[1,2,3,4];

h=[4,3,2,1];

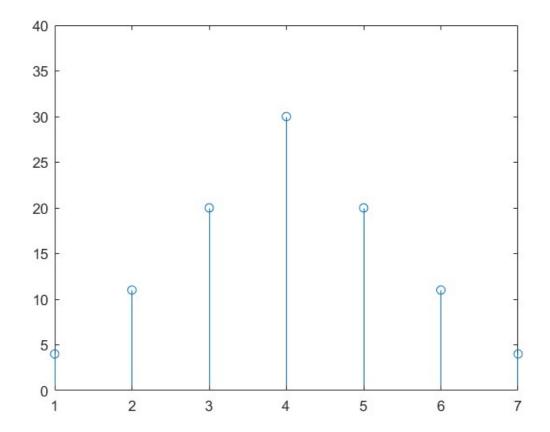
x_1=[x,zeros(1,3)];%加零

4 h_1=[h,zeros(1,3)];%加零

y=cconv(x_1,h_1);%循环卷积函数

stem(y(1:7));%去掉末尾

ylim([0,40]);
```



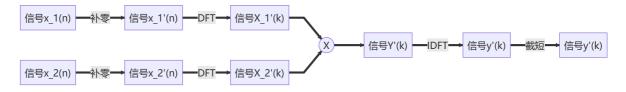
(3)

思路:

两个序列循环卷积的DFT变换为相乘,所以可以用DFT和IDFT和乘法实现两个序列的循环卷积。

循环卷积涉及到信号时域两端的干扰,因此我们需要把信号补零至长度为 N_1+N_2-1 ,进行循环卷积,然后取非零的部分,此时得到的信号与卷积是等效的

流程图如下:

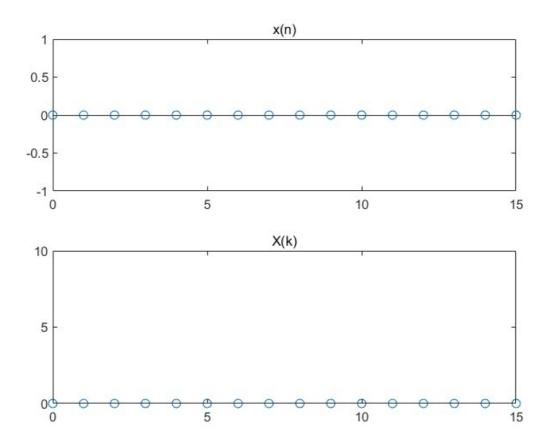


Exercise 3

(1)

```
1  f_0=50;
2  T_0=1./f_0;
3  f_s=100;
4  T_s=1./f_s;
5  N=16;
6  step_x=1:N;
7  n=step_x-1;
8  t=n.*T_s;
9  x=sin(2.*pi.*f_0.*t);
```

```
10 X=fft(x);
11
    E_t=sum(x.*x);
    E_f=2./N.*abs(X(1,(f_s./f_0)+1))^2;
12
13
    efficiency=E_f/E_t;
14
    subplot(2,1,1);
15
    stem([0:length(x)-1],x);
16
    ylim([-1,1]);
17
    title('x(n)');
18
    subplot(2,1,2);
    stem([0:length(X)-1],abs(X));
19
20
    ylim([0,10]);
21
    title('X(k)');
```



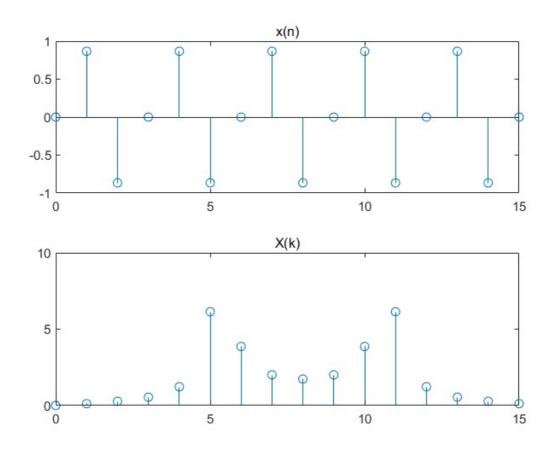
$$\eta = \frac{E_f}{E_t} = 2.16\%$$

理想情况应当是0%,但是由于计算机的精度问题存在一定误差

(2)

```
1  f_0=50;
2  T_0=1./f_0;
3  f_s=150;
4  T_s=1./f_s;
5  N=16;
6  step_x=1:N;
7  n=step_x-1;
```

```
8
      t=n.*T_s;
  9
      x=sin(2.*pi.*f_0.*t);
      X=fft(x);
 10
 11
      E_t=sum(x.*x);
 12
      E_f=2./N.*abs(X(1,(f_s./f_0)+1))^2;
 13
      efficiency=E_f/E_t;
 14
      subplot(2,1,1);
 15
      stem([0:length(x)-1],x);
 16
      ylim([-1,1]);
 17
      title('x(n)');
 18
      subplot(2,1,2);
 19
      stem([0:length(X)-1],abs(X));
 20
      ylim([0,10]);
 21
      title('X(k)');
```



$$\eta=rac{E_f}{E_t}=0.50\%$$

理想情况应当是0%,但是由于计算机的精度问题存在一定误差

(3)

```
1 | f_0=50;

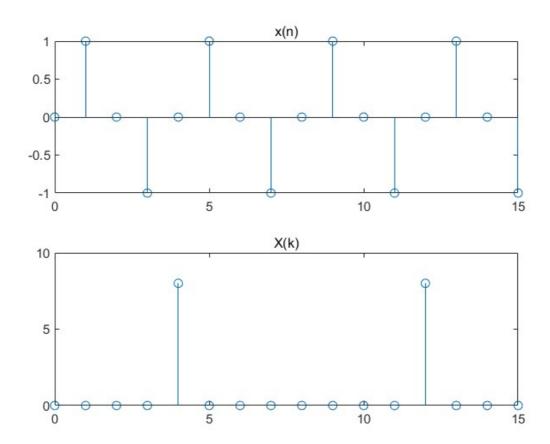
2 | T_0=1./f_0;

3 | f_s=200;

4 | T_s=1./f_s;

5 | N=16;
```

```
6
    step_x=1:N;
 7
    n=step\_x-1;
 8
    t=n.*T_s;
9
    x=sin(2.*pi.*f_0.*t);
10
    X=fft(x);
11
    E_t=sum(x.*x);
    E_f=2./N.*abs(X(1,(f_s./f_0)+1))^2;
12
13
    efficiency=E_f/E_t;
14
    subplot(2,1,1);
    stem([0:length(x)-1],x);
15
16
    ylim([-1,1]);
17
    title('x(n)');
18
    subplot(2,1,2);
19
    stem([0:length(X)-1],abs(X));
20
    ylim([0,10]);
21
    title('X(k)');
```



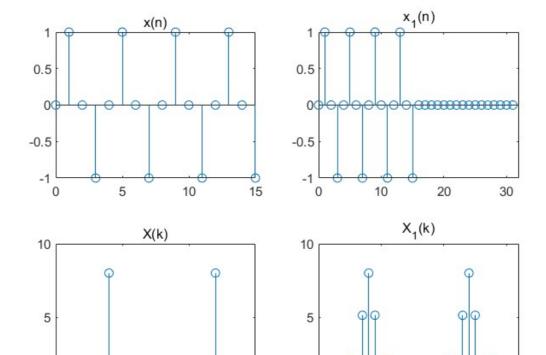
$$\eta=rac{E_f}{E_t}=100\%$$

对正弦信号抽样应当掌握的原则:抽样频率 f_s 和信号频率 f_0 应当满足 $f_s\geqslant 2f_0$

Exercise 4

```
1 | f_0=50;
2 | T_0=1./f_0;
3 | f_s=200;
```

```
4 T_s=1./f_s;
  5 N=16;
  6 step_x=1:N;
     n=step_x-1;
  7
  8
     t=n.*T_s;
  9 x=sin(2.*pi.*f_0.*t);
 10
     x_1=[x,zeros(1,N)];
 11 X=fft(x);
 12
     X_1=fft(x_1);
 13
     E_t=sum(x.*x);
 14
     E_f=2./N.*abs(X(1,(f_s./f_0)+1))^2;
 15
     efficiency=E_f/E_t;
 16
     E_t_1=sum(x_1.*x_1);
 17
     E_f_1=2./N.*abs(X_1(1,((f_s./f_0)+1)*2))^2;
 18
     efficiency_1=E_f_1/E_t_1;
 19
     subplot(2,2,1);
 20
     stem(0:length(x)-1,x);
 21
     ylim([-1,1]);
 22
     title('x(n)');
 23
     subplot(2,2,3);
     stem(0:length(X)-1,abs(X));
 25
     ylim([0,10]);
 26
     title('X(k)');
 27
     subplot(2,2,2);
 28
     stem(0:length(x_1)-1,x_1);
 29
     ylim([-1,1]);
 30
     xlim([0,32]);
 31 title('x_1(n)');
 32
     subplot(2,2,4);
 33
     stem(0:length(X_1)-1,abs(X_1));
 34
     ylim([0,10]);
 35 xlim([0,32]);
 36 title('x_1(k)');
```



$$\eta = rac{E_f}{E_t} = 100\%$$
 $\eta' = rac{E_f'}{E_t'} = 41.05\%$

10

20

正弦信号后面补零的影响有:

• DFT后的频谱不再是完美的δ函数,存在调制的分量

10

• 频谱存在泄露,效率 $\eta'=41.05\%$