4(b) 双线性Z变换法设计Chebyshev数字滤波器

（1）Chebyshev数字高通滤波器：

```
%-------------------------------------------------------------------------
% exa060603.m, for example 6.6.3;
% To design IIR Butteworth bandstop DF by analog-lowpass,
% -------------------------------------------------------------------------
clear all;

fp=300;fs=200;
%wp=[.19*pi 0.21*pi];ws=[.198*pi 0.202*pi];
Fs=1000;
rp=3;rs=30;
wp=fp*2*pi/Fs;ws=fs*2*pi/Fs;
%
% Firstly to finish frequency prewarping;
wap=2*Fs*tan(wp./2)
```

```
wap = 2.7528e+03
```

```
was=2*Fs*tan(ws./2);
[n,wn]=cheb1ord(wap,was,rp,rs,'s');
% Note: 's'!
[z,p,k]=cheb1ap(n,rp);
[b,a]=zp2tf(z,p,k)
```

```
b = 1×5
         0         0         0         0    0.1253
a = 1×5
    1.0000    0.5816    1.1691    0.4048    0.1770
```

```
%bw=wap(2)-wap(1)
%w0=sqrt(wap(1)*wap(2))
[bt,at]=lp2hp(b,a,wap)
```

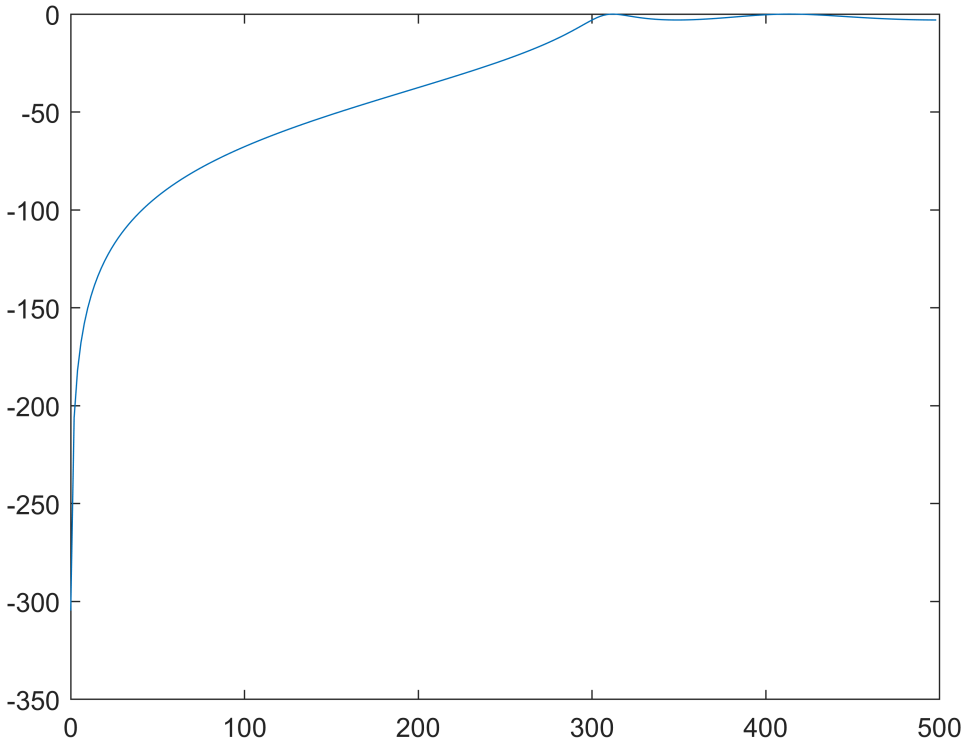
```
bt = 1×5
    0.7079   -0.0000   -0.0000   -0.0000   -0.0269
at = 1×5
10^14 ×
    0.0000    0.0000    0.0000    0.0007    3.2444
```

```
%
% Note: z=(2/ts)(z-1)/(z+1);
[bz1,az1]=bilinear(bt,at,Fs)
```

```
bz1 = 1×5
    0.0156   -0.0622    0.0933   -0.0622    0.0156
az1 = 1×5
    1.0000    1.9327    2.2554    1.4562    0.4851
```

```
[h,w]=freqz(bz1,az1,256,Fs);
figure(1)
```

```
plot(w,20*log10(abs(h)))
```



（2）Chebyshev数字低通滤波器：

```
%--------------------------------------------------------------------------
% exa060603.m, for example 6.6.3;
% To design IIR Butteworth bandstop DF by analog-lowpass,
% -------------------------------------------------------------------------
clear all;

fp=200;fs=300;
%wp=[.19*pi 0.21*pi];ws=[.198*pi 0.202*pi];
Fs=1000;
rp=3;rs=30;
wp=fp*2*pi/Fs;ws=fs*2*pi/Fs;
%
% Firstly to finish frequency prewarping;
wap=2*Fs*tan(wp./2)
```

```
wap = 1.4531e+03
```

```
was=2*Fs*tan(ws./2);
[n,wn]=cheb1ord(wap,was,rp,rs,'s');
% Note: 's'!
[z,p,k]=cheb1ap(n,rp);
[b,a]=zp2tf(z,p,k)
```

```
b = 1×5
         0         0         0         0    0.1253
a = 1×5
    1.0000    0.5816    1.1691    0.4048    0.1770
```

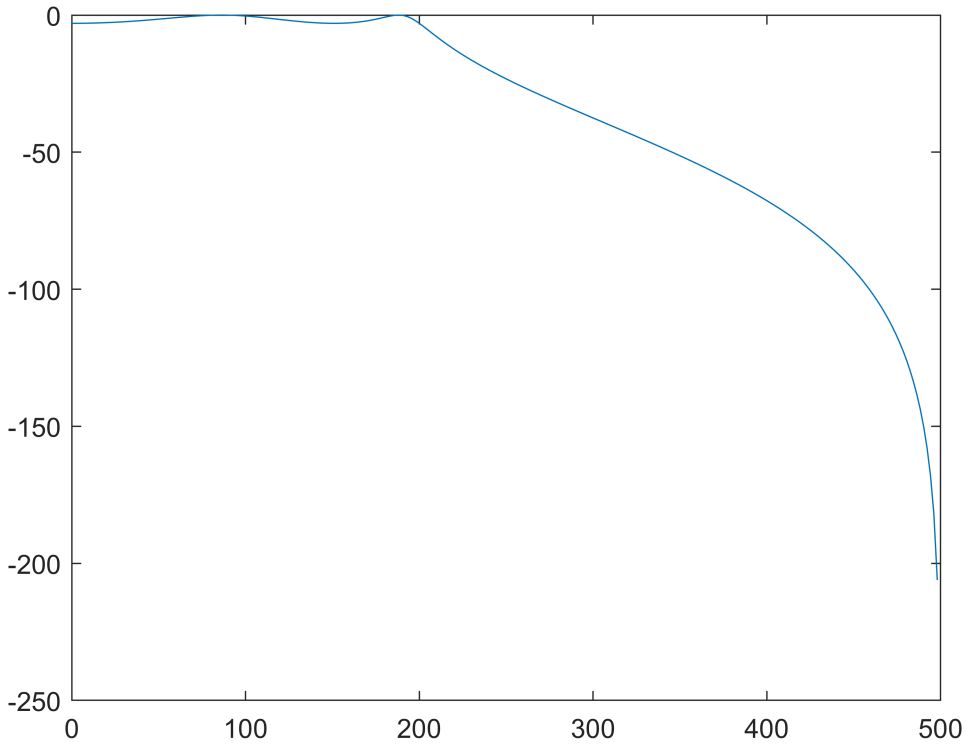
```
%bw=wap(2)-wap(1)
%w0=sqrt(wap(1)*wap(2))
[bt,at]=lp2lp(b,a,wap)
```

```
bt = 5.5861e+11
at = 1×5
10^11 ×
    0.0000    0.0000    0.0000    0.0124    7.8905
```

```
%
% Note: z=(2/ts)(z-1)/(z+1);
[bz1,az1]=bilinear(bt,at,Fs)
```

```
bz1 = 1×5
    0.0156    0.0622    0.0933    0.0622    0.0156
az1 = 1×5
    1.0000   -1.9327    2.2554   -1.4562    0.4851
```

```
[h,w]=freqz(bz1,az1,256,Fs);
figure(1)
plot(w,20*log10(abs(h)))
```



（3）Chebyshev数字带通滤波器：

```
%-------------------------------------------------------------------------
% exa060603.m, for example 6.6.3;
% To design IIR Butteworth bandstop DF by analog-lowpass,
% -------------------------------------------------------------------------
clear all;


fp=[270 330];fs=[200 400];
%wp=[.19*pi 0.21*pi];ws=[.198*pi 0.202*pi];
Fs=1000;
rp=3;rs=50;
wp=fp*2*pi/Fs;ws=fs*2*pi/Fs;
%
% Firstly to finish frequency prewarping;
wap=2*Fs*tan(wp./2)
```

```
wap = 1×2
10^3 ×
    2.2686    3.3818
```

```
was=2*Fs*tan(ws./2);
[n,wn]=cheb1ord(wap,was,rp,rs,'s');
% Note: 's'!
[z,p,k]=cheb1ap(n,rp);
[b,a]=zp2tf(z,p,k)
```

```
b = 1×5
         0         0         0         0    0.1253
a = 1×5
    1.0000    0.5816    1.1691    0.4048    0.1770
```

```
bw=wap(2)-wap(1)
```

```
bw = 1.1133e+03
```

```
w0=sqrt(wap(1)*wap(2))
```

```
w0 = 2.7698e+03
```

```
[bt,at]=lp2bp(b,a,w0,bw)
```

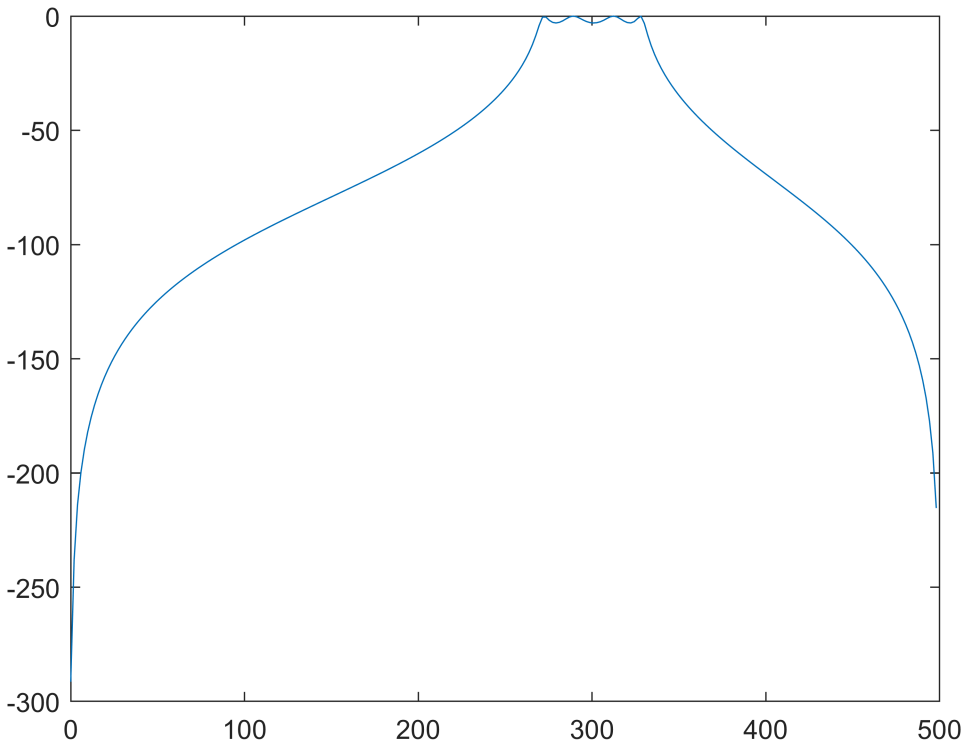
```
bt = 1×5
10^11 ×
    1.9245    0.0000   -0.0000   -0.0000   -0.0013
at = 1×9
10^27 ×
    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0003 ···
```

```
%
% Note: z=(2/ts)(z-1)/(z+1);
```

```
[bz1,az1]=bilinear(bt,at,Fs)
```

```
bz1 = 1×9
10^-3 ×
    0.1435    0.0000   -0.5738    0.0000    0.8608    0.0000   -0.5738    0.0000 ···
az1 = 1×9
    1.0000    2.4050    5.8270    7.5438    9.3294    7.1430    5.2252    2.0398 ···
```

```
[h,w]=freqz(bz1,az1,256,Fs);
figure(1)
plot(w,20*log10(abs(h)))
```



（4）Chebyshev数字带阻滤波器：

```
%------------------------------------------------------------------------
% exa060603.m, for example 6.6.3;
% To design IIR Butteworth bandstop DF by analog-lowpass,
% ------------------------------------------------------------------------
clear all;


fp=[200 400];fs=[270 330];
%wp=[.19*pi 0.21*pi];ws=[.198*pi 0.202*pi];
Fs=1000;
rp=3;rs=50;
```

```
wp=fp*2*pi/Fs;ws=fs*2*pi/Fs;
%
% Firstly to finish frequency prewarping;
wap=2*Fs*tan(wp./2)
```

```
wap = 1×2
10^3 ×
    1.4531    6.1554
```

```
was=2*Fs*tan(ws./2);
[n,wn]=cheb1ord(wap,was,rp,rs,'s');
% Note: 's'!
[z,p,k]=cheb1ap(n,rp);
[b,a]=zp2tf(z,p,k)
```

```
b = 1×5
         0         0         0         0    0.1253
a = 1×5
    1.0000    0.5816    1.1691    0.4048    0.1770
```

```
bw=wap(2)-wap(1)
```

```
bw = 4.7023e+03
```

```
w0=sqrt(wap(1)*wap(2))
```

```
w0 = 2.9907e+03
```

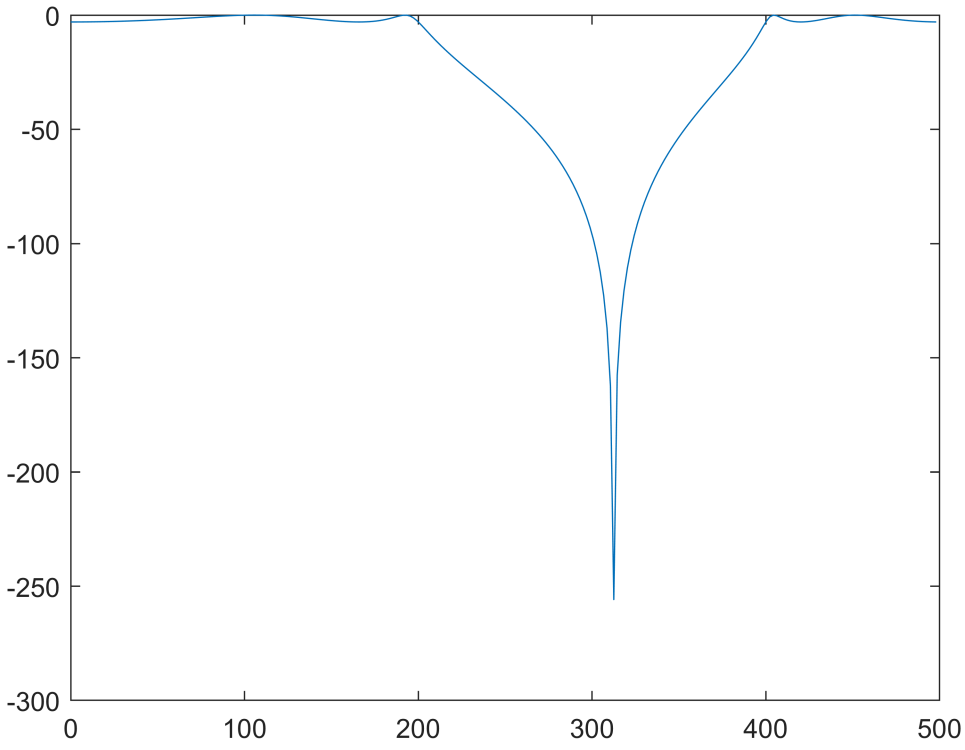
```
[bt,at]=lp2bs(b,a,w0,bw)
```

```
bt = 1×9
10^27 ×
    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000   -0.0000 ···
at = 1×9
10^27 ×
    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0077 ···
```

```
%
% Note: z=(2/ts)(z-1)/(z+1);
[bz1,az1]=bilinear(bt,at,Fs)
```

```
bz1 = 1×9
    0.0788    0.2408    0.5912    0.8630    1.0516    0.8630    0.5912    0.2408 ···
az1 = 1×9
    1.0000    1.4643    0.7738    0.8108    1.3076    0.4411   -0.0526    0.4021 ···
```

```
[h,w]=freqz(bz1,az1,256,Fs);
figure(1)
plot(w,20*log10(abs(h)))
```


0
-50
-100
-150
-200
-250
-300
0
100
200
300
400
500