① 未量化(32 位量化)，14 位量化，8 位量化系数求系统函数；

图：

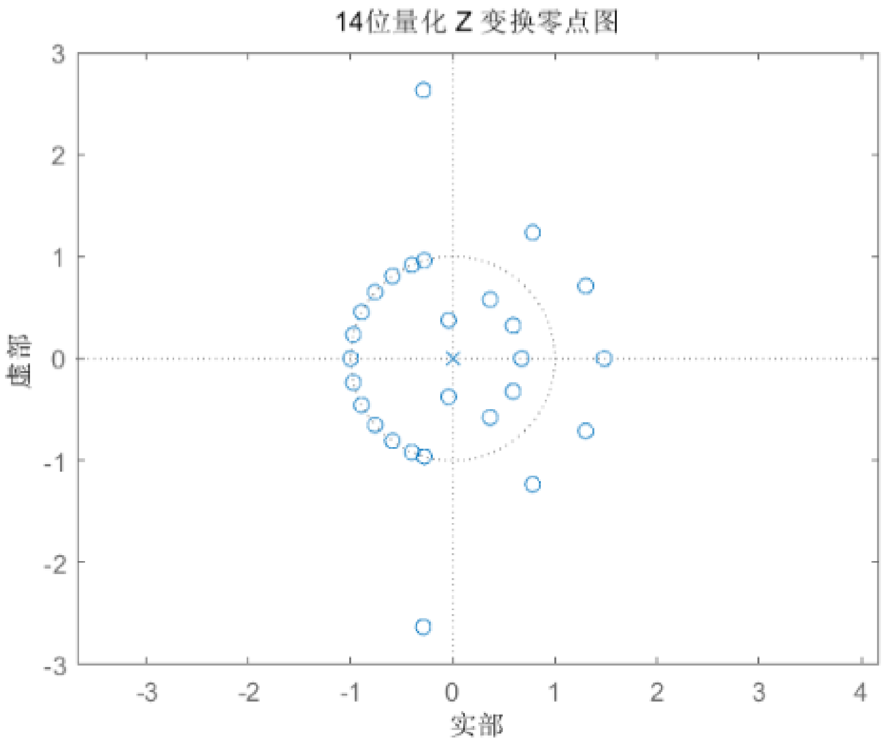
```
Hz = tf(h,1,1,'variable','z^-1')

Hz =

  0.00136 - 0.001617 z^-1 - 0.007738 z^-2 - 0.002687 z^-3 + 0.001255 z^-4 + 0.006592 z^-5 - 0.02218 z^-6 - 0.01525 z^-7

          + 0.03721 z^-8 + 0.03233 z^-9 - 0.06537 z^-10 - 0.07529 z^-11 + 0.1561 z^-12 + 0.4394 z^-13 + 0.4394 z^-14

          + 0.1561 z^-15 - 0.07529 z^-16 - 0.06537 z^-17 + 0.03233 z^-18 + 0.03721 z^-19 - 0.01525 z^-20 - 0.02218 z^-21

                    + 0.006592 z^-22 + 0.001255 z^-23 - 0.002687 z^-24 - 0.007738 z^-25 - 0.001617 z^-26 + 0.00136 z^-27

Sample time: 1 seconds
Discrete-time transfer function.
Hz_14 = tf(h_14bits,1,1,'variable','z^-1')

Hz_14 =

  -0.001343 - 0.001587 z^-1 - 0.00769 z^-2 - 0.002686 z^-3 + 0.01257 z^-4 + 0.006592 z^-5 - 0.02222 z^-6 - 0.01526 z^-7

          + 0.03723 z^-8 + 0.03235 z^-9 - 0.06543 z^-10 - 0.07532 z^-11 + 0.1561 z^-12 + 0.4395 z^-13 + 0.4395 z^-14

          + 0.1561 z^-15 - 0.07532 z^-16 - 0.06543 z^-17 + 0.03235 z^-18 + 0.03723 z^-19 - 0.01526 z^-20 - 0.02222 z^-21

                     + 0.006592 z^-22 + 0.01257 z^-23 - 0.002686 z^-24 - 0.00769 z^-25 - 0.001587 z^-26 - 0.001343 z^-27

Sample time: 1 seconds
Discrete-time transfer function.
Hz_8 = tf(h_8bits,1,1,'variable','z^-1')

Hz_8 =

  -0.007813 z^-2 + 0.01563 z^-4 + 0.007813 z^-5 - 0.02344 z^-6 - 0.01563 z^-7 + 0.03906 z^-8 + 0.03125 z^-9 - 0.0625 z^-10

          - 0.07813 z^-11 + 0.1563 z^-12 + 0.4375 z^-13 + 0.4375 z^-14 + 0.1563 z^-15 - 0.07813 z^-16 - 0.0625 z^-17

          + 0.03125 z^-18 + 0.03906 z^-19 - 0.01563 z^-20 - 0.02344 z^-21 + 0.007813 z^-22 + 0.01563 z^-23 - 0.007813 z^-25


Sample time: 1 seconds
Discrete-time transfer function.
```

代码：

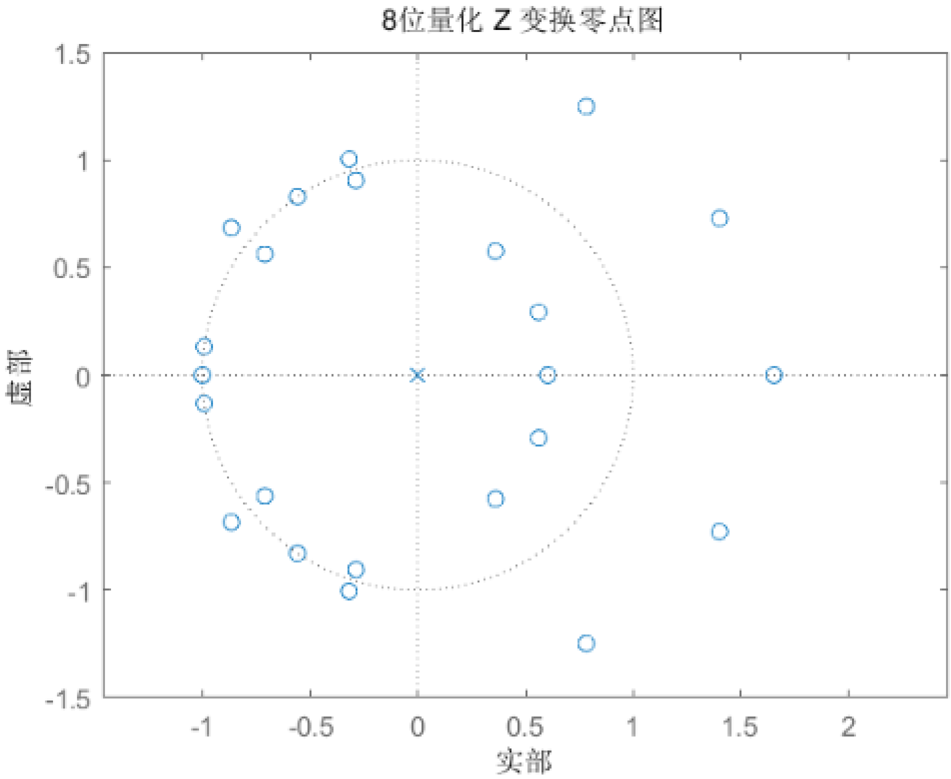
```
format long
h1 = [1.359657e-3,-1.616993e-3,-7.738032e-3,-2.686841e-3,1.255246e-3,...
6.591530e-3,-2.217952e-2,-1.524663e-2,3.720668e-2,3.233332e-2,-6.537057e-2,-7.528754e-2,...
1.560970e-1,4.394094e-1];
h2 = flip(h1);
h = [h1,h2];
%14bits
format long
h1 = [-11,-13,-63,-22,103,54,-182,-125,305,265,-536,-617,1279,3600]*2^(-13);
h2 = flip(h1);
h_14bits = [h1,h2];
%8bits
```

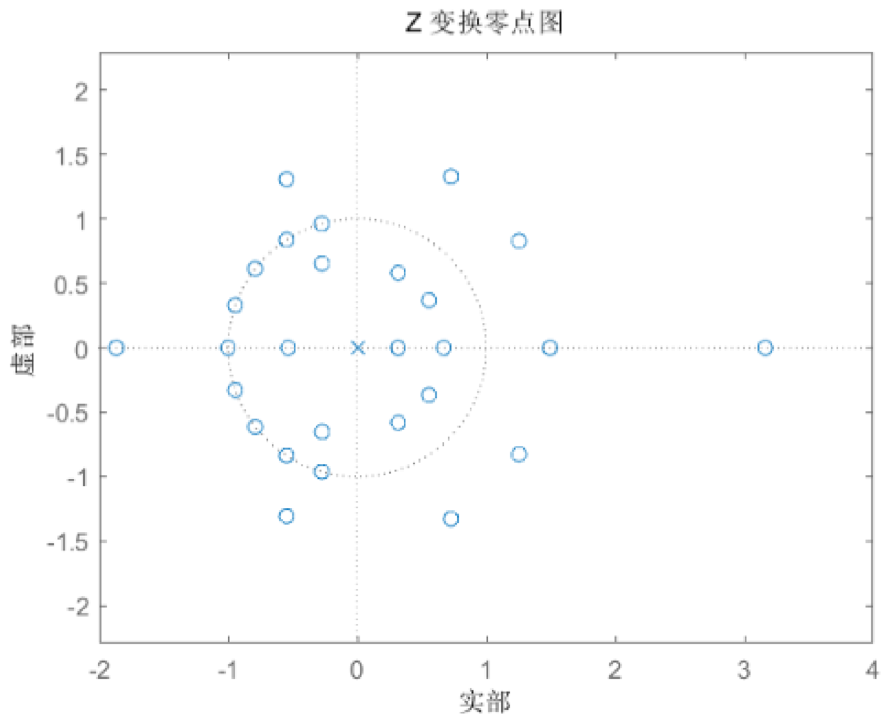
```
format long
h1 = [0,0,-1,0,2,1,-3,-2,5,4,-8,-10,20,56]*2^(-7);
h2 = flip(h1);
h_8bits = [h1,h2];
% 第一题
syms z
n = 0:27;
Hz = sum(h.*z.^(-n));
Hz_8 = sum(h_8bits.*z.^(-n));
Hz_14 = sum(h_14bits.*z.^(-n));
```

② 系统函数，求出零点（分母设为 z-27 ），并画零点图；
图：



代码：





代码：

```
1. zero_n = roots(h);
2. zero_14 = roots(h_14bits);
```

```
zero_8 = roots(h_8bits);
%plot the map
figure;
zplane(h,1);
title('Z 变换零点图');

xlabel('实部');
ylabel('虚部');

figure;
zplane(h_14bits,1);
title('14 位量化 Z 变换零点图');

xlabel('实部');
ylabel('虚部');
figure;
zplane(zero_8,1);
title('8 位量化 Z 变换零点图');
xlabel('实部');
ylabel('虚部');
```

③ 零点，求出系统函数因式形式；
图：

```
tf_n =
```

$$\left(z+\frac{4914569269854561}{18014398509481984}-\frac{1467314696391483}{2251799813685248}\,\mathrm{i}\right)\left(z+\frac{4914569269854561}{18014398509481984}+\frac{1467314696391483}{2251799813685248}\,\mathrm{i}\right)\left(z+\frac{2126752620127609}{2251799813685248}-\frac{739949791332665}{2251799813685248}\,\mathrm{i}\right)\left(z+\frac{2126752620127609}{2251799813685248}+\frac{739949791332665}{2251799813685248}\,\mathrm{i}\right)\left(z+\frac{24677032}{45035996}\right.$$

```
%14bits
tf_14 = 1;
for n = 1:27
    tf_14 = (z-zero_14(n)).*tf_14;
end
tf_14
```

```
tf_14 =
```

$$\left(z-\frac{1518362172708057}{2251799813685248}\right)\left(z+\frac{2504698108643431}{9007199254740992}-\frac{4325971734742513}{4503599627370496}\,\mathrm{i}\right)\left(z+\frac{2504698108643431}{9007199254740992}+\frac{4325971734742513}{4503599627370496}\,\mathrm{i}\right)\left(z-\frac{1466308105702161}{1125899906842624}-\frac{3201871562229859}{4503599627370496}\,\mathrm{i}\right)\left(z-\frac{1466308105702161}{1125899906842624}+\frac{32018715622}{45035996273}\right.$$

```
%8bits
tf_8 = 1;
for n = 1:23
    tf_8 = (z-zero_8(n)).*tf_8;
end
tf_8
```

```
tf_8 =
```

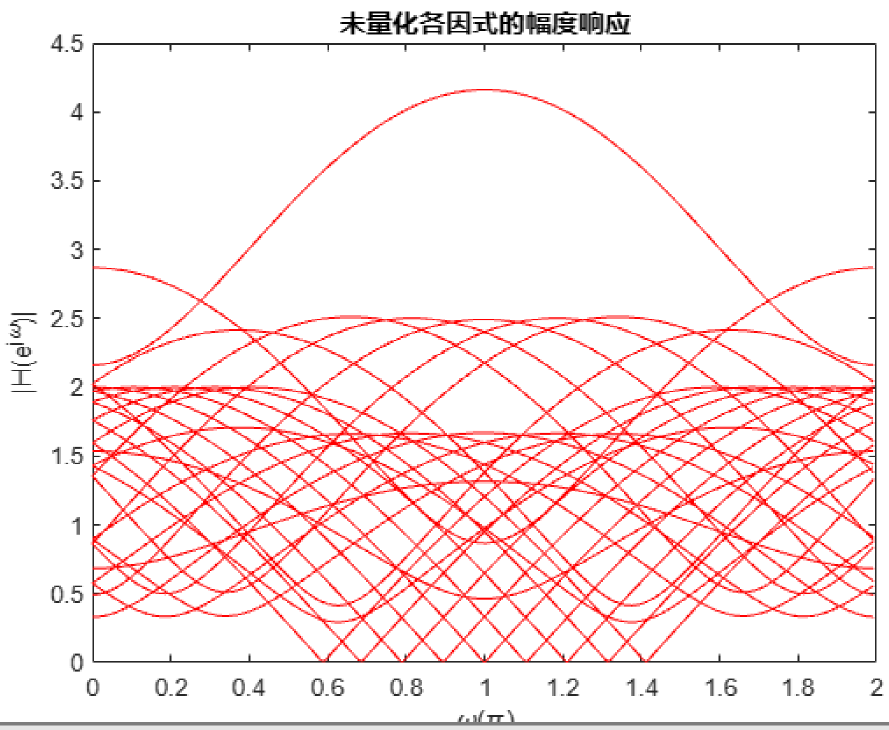
$$\left(z-\frac{1264971435332211}{2251799813685248}-\frac{2626604863838265}{9007199254740992}\,\mathrm{i}\right)\left(z-\frac{1264971435332211}{2251799813685248}+\frac{2626604863838265}{9007199254740992}\,\mathrm{i}\right)\left(z-\frac{340102454778589}{562949953421312}\right)\left(z-\frac{3727260954507027}{2251799813685248}\right)\left(z+\frac{5048285007548739}{9007199254740992}-\frac{7459521224392701}{9007199254740992}\,\mathrm{i}\right)\left(z+\frac{50482850}{90071992}\right.$$

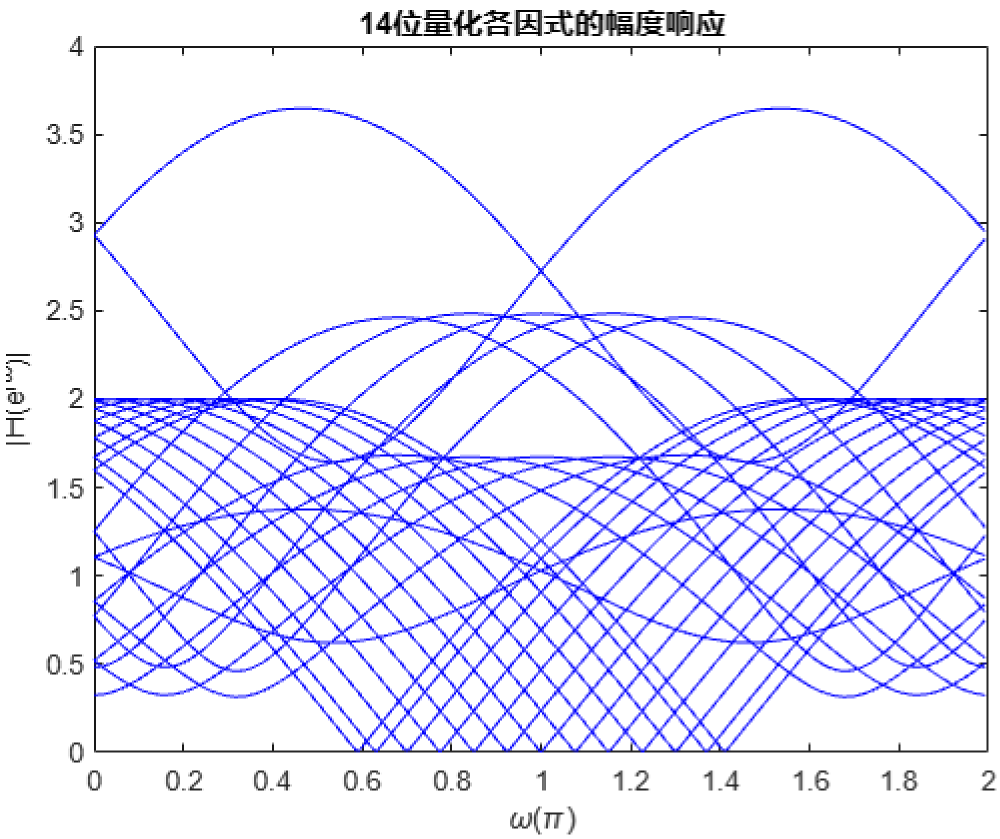
```
%no quantilize
tf_n = 1;
for n = 1:27
tf_n = (z-zero_n(n)).*tf_n;
end
tf_n
%14bits
tf_14 = 1;
```

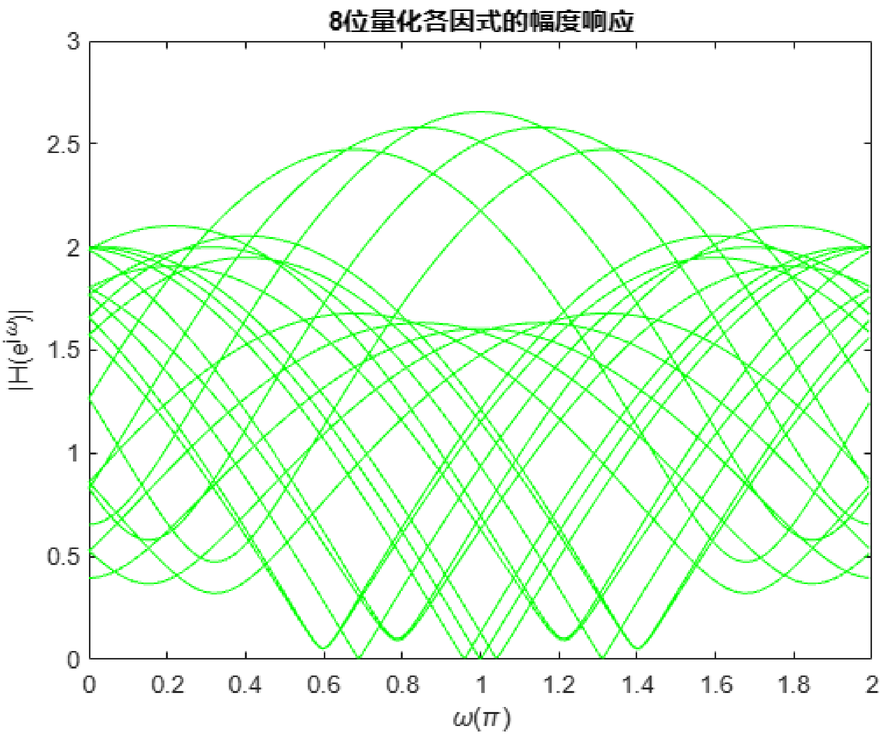
```
for n = 1:27
tf_14 = (z-zero_14(n)).*tf_14;
end
tf_14
%8bits
tf_8 = 1;
for n = 1:25
tf_8 = (z-zero_8(n)).*tf_8;
end
tf_8
```

④ 系统函数各子因式，画出各因式对应的幅度响应|Hk(ejω)|；

图：





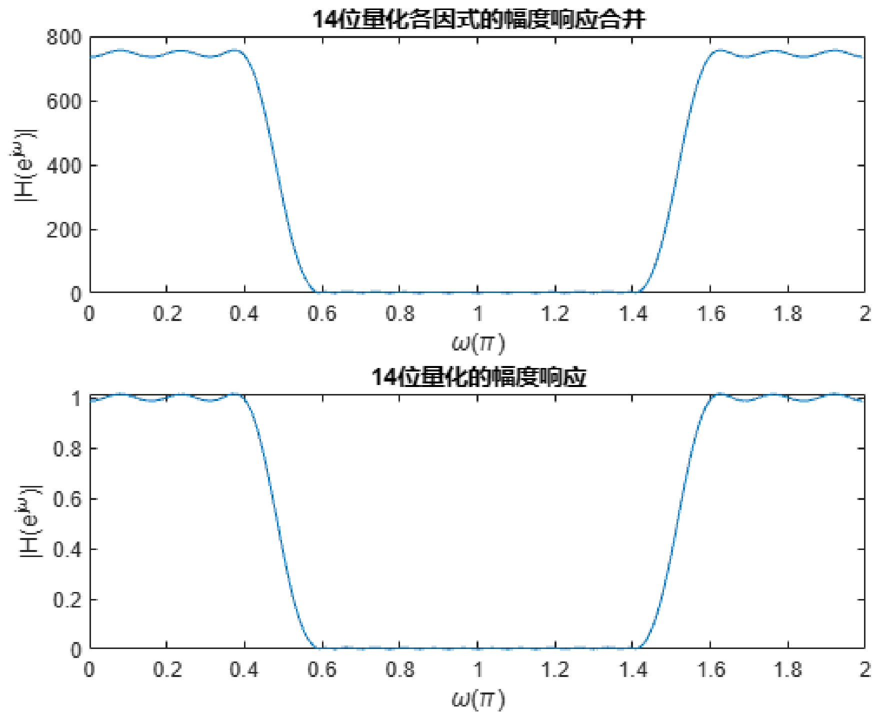



```
% no quantilize
figure;
clear title;
```

```
H_factor = zeros(27,256);
for i = 1:27
[H_subfactor,w] = freqz([1 -zero_n(i)],1,256,'whole');
H_factor(i,:) = H_subfactor';
end
for j = 1:27
plot(w,abs(H_factor(j,:)));
hold on;
end
title('未量化')
figure;
H_factor = zeros(25,256);
for i = 1:25
[H_subfactor,w] = freqz([1 -zero_14(i)],1,256,'whole');
H_factor(i,:) = H_subfactor';
end
for j = 1:25
8
plot(w,abs(H_factor(j,:)));
hold on;
end
title('十四位量化')
figure;
H_factor = zeros(25,256);
for i = 1:25
[H_subfactor,w] = freqz([1 -zero_8(i)],1,256,'whole');
H_factor(i,:) = H_subfactor';
end
for j = 1:25
plot(w,abs(H_factor(j,:)));
hold on;
end
title('八位量化')
```

⑤画出 ④生成的由 14 位量化各因式幅度响应合并的系统幅度响应|H14(ejω)|，并与由①中求得的系统函数直接获得的幅度响应进行比较，给出结论描述；

图：

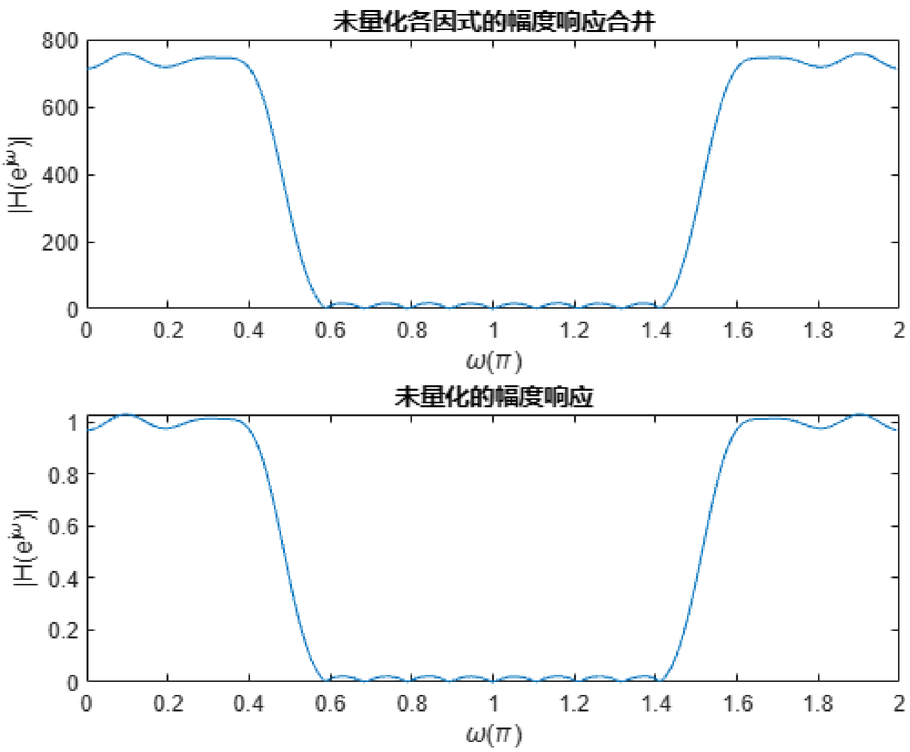



```
H_factor_14_product = prod(abs(H_factor_14),1);
figure(7);
subplot(2,1,1)
plot(w/pi,abs(H_factor_14_product));
title('14 位量化各因式的幅度响应合并');
xlabel('\omega(\pi)');
ylabel ('|H(e^j^\omega)|');
subplot(2,1,2)
[H_f14,~] = freqz(h_14bits,1,256,'whole');
plot(w/pi,abs(H_f14));
title('14 位量化的幅度响应');
xlabel('\omega(\pi)');
ylabel ('|H(e^j^\omega)|')
```

⑤

⑥ 对未量化系统，重做步骤⑤过程，并与 14 位量化幅度响应进行比较，并给出结论描述。

图



代码:

```
H_factor_n_product = prod(abs(H_factor),1);
figure(8);
subplot(2,1,1)
plot(w/pi,abs(H_factor_n_product));
title('未量化各因式的幅度响应合并');
xlabel('\omega(\pi)');
ylabel ('|H(e^j^\omega)|');
subplot(2,1,2)
[H,~] = freqz(h,1,256,'whole');
plot(w/pi,abs(H));
title('未量化的幅度响应');
xlabel('\omega(\pi)');
ylabel ('|H(e^j^\omega)|');
```