HW8 MATLAB code

1.

hn = [-4, 1, -1, -2, 5, 6, 6, 5, -2, -1, 1, -4];

N = length(hn);

n = 0:N-1;

w = 0:2\*pi/600:2\*pi;

H = sum(hn'.\*exp(-1i\*w.\*n'),1);

figure(1);

plot(w,abs(H));

title('Magnitude of H(e^{j\omega})');

xlabel('\omega');

ylabel('|H(e^{j\omega}|');

xlim([0,2\*pi]);

set(gca,'XTick',0:pi/2:2\*pi);

set(gca,'XTickLabel',{'0','\pi/2','\pi','3\pi/2','2\pi'});

figure(2);

plot(w,angle(H));

title('Phase of H(e^{j\omega})');

xlabel('\omega');

ylabel('\angleH(e^{j\omega})');

xlim([0,2\*pi]);

set(gca,'XTick',0:pi/2:2\*pi);

set(gca,'XTickLabel',{'0','\pi/2','\pi','3\pi/2','2\pi'});

theta = -(N-1)/2\*w;

A = H./exp(1i\*theta);

figure(3);

plot(w,A);

title('Amplitude function A(\omega)');

xlabel('\omega');

ylabel('A(\omega)');

xlim([0,2\*pi]);

set(gca,'XTick',0:pi/2:2\*pi);

set(gca,'XTickLabel',{'0','\pi/2','\pi','3\pi/2','2\pi'});

figure(4);

plot(w,theta);

title('Phase function \theta(\omega)');

xlabel('\omega');

ylabel('\theta(\omega)');

xlim([0,2\*pi]);

set(gca,'XTick',0:pi/2:2\*pi);

set(gca,'XTickLabel',{'0','\pi/2','\pi','3\pi/2','2\pi'});

Hz = tf(hn,1,-1,'Variable','z^-1');

[p,z] = pzmap(Hz);

figure(5);

pzmap(Hz);

axis equal;

M = (N-1)/2;

Ak = A(1+(600/N)\*n);

h\_n = (Ak(1) + sum(2\*Ak(2:N/2).\*cos(2\*pi\*(n-M)'.\*(1:N/2-1)/N),2))/N;

(a)

Chart, line chart, histogram

Description automatically generatedChart, line chart, histogram

Description automatically generated

(b)

Chart, line chart

Description automatically generatedChart, line chart

Description automatically generated

(c)

Chart

Description automatically generated

(d)

Text, letter

Description automatically generatedText, letter

Description automatically generated

2.

N = 41;

M = (N-1)/2;

k = 0:M;

w = k\*2\*pi/N;

Ak = 1\*(w>=pi/3 & w<=2\*pi/3);

hn = (Ak(1) + sum(2\*Ak(2:end)'.\*cos(2\*pi\*((0:N-1)-M).\*k(2:end)'/N),1))/N;

omega = linspace(0,2\*pi,1e3);

H = sum(hn'.\*exp(-1i\*(0:N-1)'.\*omega),1);

figure(1);

stem((0:N-1),hn,'.');

title('h[n]');

xlabel('n');

ylabel('h[n]');

figure(2);

subplot(2,1,1);

stem(w,Ak,'.');

hold on;

plot(omega,abs(H));

title('A\_k and |H(e^{j\omega})|, no transition point');

xlabel('\omega');

ylabel('|H(e^{j\omega})|');

xlim([0,2\*pi]);

legend('A\_k', '|H(e^{j\omega})|');

set(gca,'XTick',0:pi/3:2\*pi);

set(gca,'XTickLabel',{'0','\pi/3','2\pi/3','\pi','4\pi/3','5\pi/3','2\pi'});

subplot(2,1,2);

plot(omega,angle(H));

title('\angleH(e^{j\omega}), no transition point');

xlabel('\omega');

ylabel('\angleH(e^{j\omega})');

xlim([0,2\*pi]);

set(gca,'XTick',0:pi/3:2\*pi);

set(gca,'XTickLabel',{'0','\pi/3','2\pi/3','\pi','4\pi/3','5\pi/3','2\pi'});

Ak(find(w<pi/3,1,"last")) = 0.3904;

Ak(find(w>2\*pi/3,1,"first")) = 0.3904;

hn = (Ak(1) + sum(2\*Ak(2:end)'.\*cos(2\*pi\*((0:N-1)-M).\*k(2:end)'/N),1))/N;

H = sum(hn'.\*exp(-1i\*(0:N-1)'.\*omega),1);

figure(3);

stem((0:N-1),hn,'.');

title('h[n]');

xlabel('n');

ylabel('h[n]');

figure(4);

subplot(2,1,1);

stem(w,Ak,'.');

hold on;

plot(omega,abs(H));

title('A\_k and |H(e^{j\omega})|, with one transition point');

xlabel('\omega');

ylabel('|H(e^{j\omega})|');

xlim([0,2\*pi]);

legend('A\_k', '|H(e^{j\omega})|');

set(gca,'XTick',0:pi/3:2\*pi);

set(gca,'XTickLabel',{'0','\pi/3','2\pi/3','\pi','4\pi/3','5\pi/3','2\pi'});

subplot(2,1,2)

plot(omega,angle(H));

title('\angleH(e^{j\omega}), with one transition point');

xlabel('\omega');

ylabel('\angleH(e^{j\omega})');

xlim([0,2\*pi]);

set(gca,'XTick',0:pi/3:2\*pi);

set(gca,'XTickLabel',{'0','\pi/3','2\pi/3','\pi','4\pi/3','5\pi/3','2\pi'});

Ak(find(w<pi/3,2,"last")) = [1/4 3/4];

Ak(find(w>2\*pi/3,2,"first")) = [3/4 1/4];

hn = (Ak(1) + sum(2\*Ak(2:end)'.\*cos(2\*pi\*((0:N-1)-M).\*k(2:end)'/N),1))/N;

H = sum(hn'.\*exp(-1i\*(0:N-1)'.\*omega),1);

figure(5);

stem((0:N-1),hn,'.');

title('h[n]');

xlabel('n');

ylabel('h[n]');

figure(6);

subplot(2,1,1);

stem(w,Ak,'.');

hold on;

plot(omega,abs(H));

title('A\_k and |H(e^{j\omega})|, with one transition point');

xlabel('\omega');

ylabel('|H(e^{j\omega})|');

xlim([0,2\*pi]);

legend('A\_k', '|H(e^{j\omega})|');

set(gca,'XTick',0:pi/3:2\*pi);

set(gca,'XTickLabel',{'0','\pi/3','2\pi/3','\pi','4\pi/3','5\pi/3','2\pi'});

subplot(2,1,2);

plot(omega,angle(H));

title('\angleH(e^{j\omega}), N=41 with two transition points');

xlabel('\omega');

ylabel('\angleH(e^{j\omega})');

xlim([0,2\*pi]);

set(gca,'XTick',0:pi/3:2\*pi);

set(gca,'XTickLabel',{'0','\pi/3','2\pi/3','\pi','4\pi/3','5\pi/3','2\pi'});

(a)

Chart, box and whisker chart

Description automatically generatedGraphical user interface, chart, histogram

Description automatically generated

(b)

Chart

Description automatically generatedGraphical user interface, histogram

Description automatically generated

(c)

Chart, box and whisker chart

Description automatically generatedGraphical user interface, chart, histogram

Description automatically generated

根據以上三種情況比較，取樣時加入transition point可以讓ripple變小，同時防止Gibb’s phenomenon發生。

3.

N = 40;

alpha = (N-1)/2;

k = 0:N/2-1;

w = k\*2\*pi/N;

Ak = 1\*(w >= 0 & w <= pi/2);

hd = sin(pi/2\*(k-alpha))./(pi\*(k-alpha));

win1 = rectwin(N)';

hn = hd.\*win1(1:N/2);

omega = linspace(0,2\*pi,1e3);

hn = cat(2,hn,hn(end:-1:1));

H = sum(hn'.\*exp(-1i\*(0:N-1)'.\*omega),1);

figure(1);

stem((0:N-1),hn,'.');

title('h[n]');

xlabel('n');

ylabel('h[n]');

figure(2);

subplot(2,1,1);

stem(w,Ak,'.');

hold on;

plot(omega,abs(H));

title('A\_k and |H(e^{j\omega})|, Rectangular window');

xlabel('\omega');

ylabel('|H(e^{j\omega})|');

xlim([0,2\*pi]);

legend('A\_k', '|H(e^{j\omega})|');

set(gca,'XTick',0:pi/3:2\*pi);

set(gca,'XTickLabel',{'0','\pi/3','2\pi/3','\pi','4\pi/3','5\pi/3','2\pi'});

subplot(2,1,2);

plot(omega,angle(H));

title('\angleH(e^{j\omega}), Rectangular window');

xlabel('\omega');

ylabel('\angleH(e^{j\omega})');

xlim([0,2\*pi]);

set(gca,'XTick',0:pi/2:2\*pi);

set(gca,'XTickLabel',{'0','\pi/2','\pi','3\pi/2','2\pi'});

win2 = hanning(N)';

hn = hd.\*win2(1:N/2);

hn = cat(2,hn,hn(end:-1:1));

H = sum(hn'.\*exp(-1i\*(0:N-1)'.\*omega),1);

figure(3);

stem((0:N-1),hn,'.');

title('h[n]');

xlabel('n');

ylabel('h[n]');

figure(4);

subplot(2,1,1);

stem(w,Ak,'.');

hold on;

plot(omega,abs(H));

title('A\_k and |H(e^{j\omega})|, Hanning window');

xlabel('\omega');

ylabel('|H(e^{j\omega})|');

xlim([0,2\*pi]);

legend('A\_k', '|H(e^{j\omega})|');

set(gca,'XTick',0:pi/3:2\*pi);

set(gca,'XTickLabel',{'0','\pi/3','2\pi/3','\pi','4\pi/3','5\pi/3','2\pi'});

subplot(2,1,2);

plot(omega,angle(H));

title('\angleH(e^{j\omega}), Hanning window');

xlabel('\omega');

ylabel('\angleH(e^{j\omega})');

xlim([0,2\*pi]);

set(gca,'XTick',0:pi/2:2\*pi);

set(gca,'XTickLabel',{'0','\pi/2','\pi','3\pi/2','2\pi'});

win3 = blackman(N)';

hn = hd.\*win3(1:N/2);

hn = cat(2,hn,hn(end:-1:1));

H = sum(hn'.\*exp(-1i\*(0:N-1)'.\*omega),1);

figure(5);

stem((0:N-1),hn,'.');

title('h[n]');

xlabel('n');

ylabel('h[n]');

figure(6);

subplot(2,1,1);

stem(w,Ak,'.');

hold on;

plot(omega,abs(H));

title('A\_k and |H(e^{j\omega})|, Blackman window');

xlabel('\omega');

ylabel('|H(e^{j\omega})|');

xlim([0,2\*pi]);

legend('A\_k', '|H(e^{j\omega})|');

set(gca,'XTick',0:pi/3:2\*pi);

set(gca,'XTickLabel',{'0','\pi/3','2\pi/3','\pi','4\pi/3','5\pi/3','2\pi'});

subplot(2,1,2);

plot(omega,angle(H));

title('\angleH(e^{j\omega}), Blackman window');

xlabel('\omega');

ylabel('\angleH(e^{j\omega})');

xlim([0,2\*pi]);

set(gca,'XTick',0:pi/2:2\*pi);

set(gca,'XTickLabel',{'0','\pi/2','\pi','3\pi/2','2\pi'});

(a)

Chart

Description automatically generatedGraphical user interface

Description automatically generated

(b)

Chart, histogram

Description automatically generatedGraphical user interface, chart, histogram

Description automatically generated

(c)

Chart, histogram

Description automatically generatedGraphical user interface, chart, histogram

Description automatically generated

利用windowing取樣可以有效減少ripple和防止Gibb’s phenomenon，但transition band會變寬。