EL 7133 (DSP II)
Spring 2016
Homework Assignment - Week 03

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Question Part B

The problem: For d = 1, 3, 5, find Q(z) such H(z) above is a Type I halfband filter. For d = 1 the problem is trivial. For d = 3 you can solve the linear equations problem by hand. For d = 5 you can use MATLAB to solve the system of linear equations.

In each case, check that h(n) really is a halfband filter, make a stem plot of h(n), and include the zero diagram and frequency response |Hf (ω)|. 1

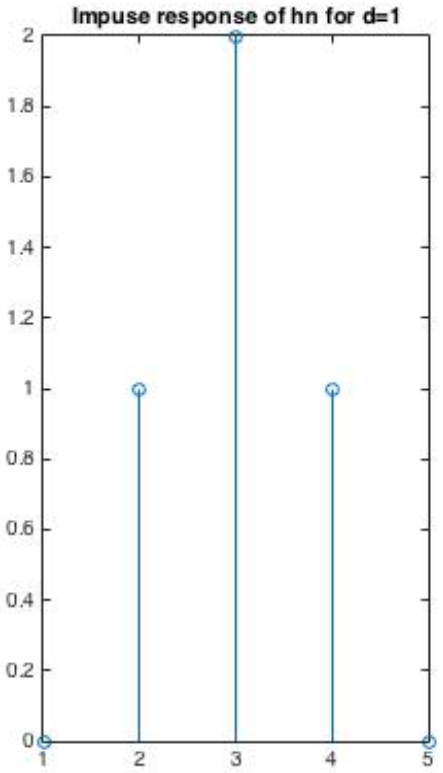
Solution

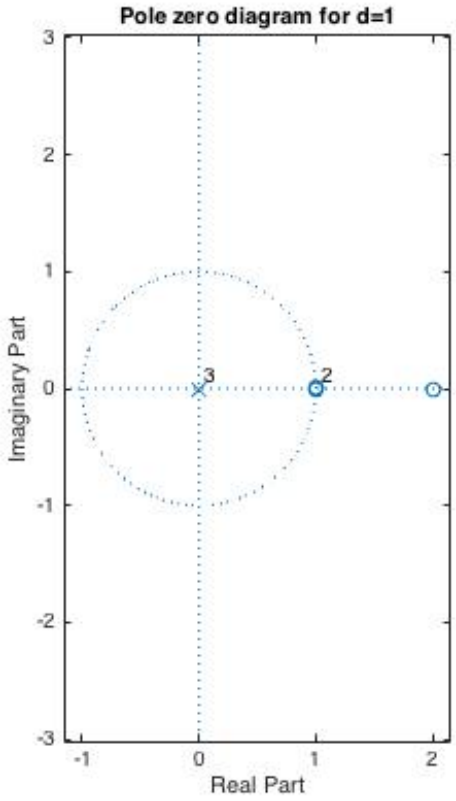
Program

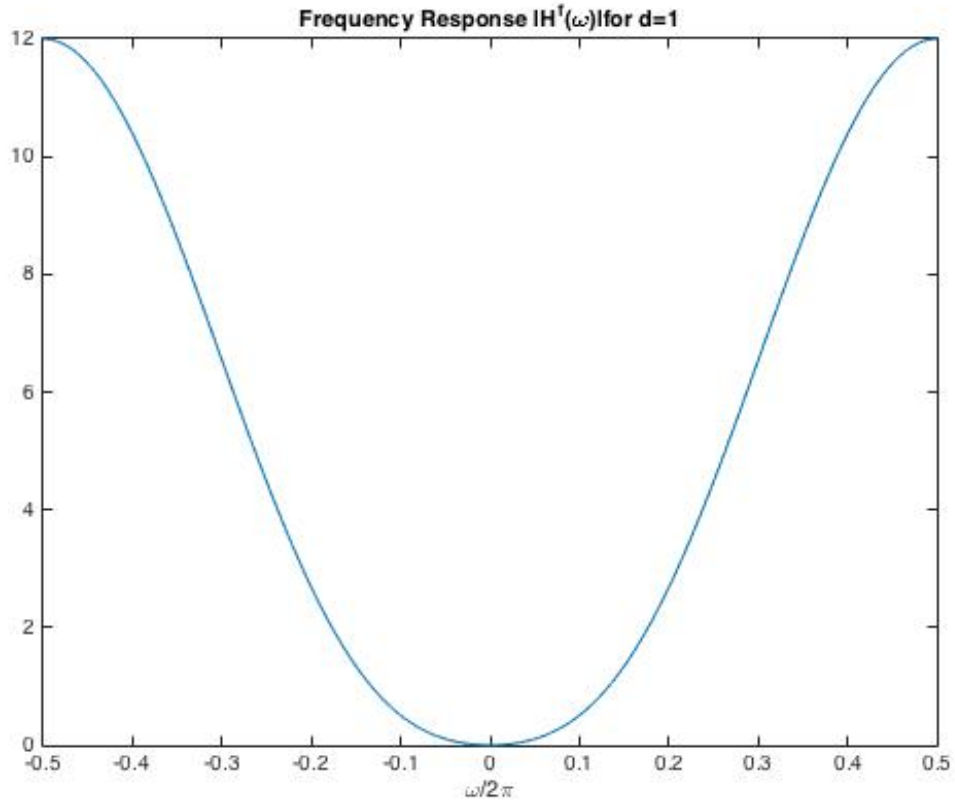
For d=1;

```
clc;clear all; close all;
% for d=1
d=1;
q=[0.5 0]
p=[1 1];
p1=[1 1];
for i=1:d
    p=conv(p,p1);
end
hn=conv(q,p)

b=poly(hn);
a=1;

% Stem plot
figure,subplot(1,2,1), stem(hn);
title(['Impuse response of hn for d=' num2str(d)]);

% Pole zero diagram
subplot(1,2,2), zplane(b,a)
title(['Pole zero diagram for d=' num2str(d)]);

% Frequency Response
j=sqrt(-1);
om=linspace(-pi,pi,200);
Hf=polyval(b,exp(j*om))./polyval(a,exp(j*om));
figure,plot(om/(2*pi),abs(Hf))
title(['Frequency Response |H^f(\omega)|for d=',num2str(d)]);
xlabel('\omega/2\pi');
```

Result:



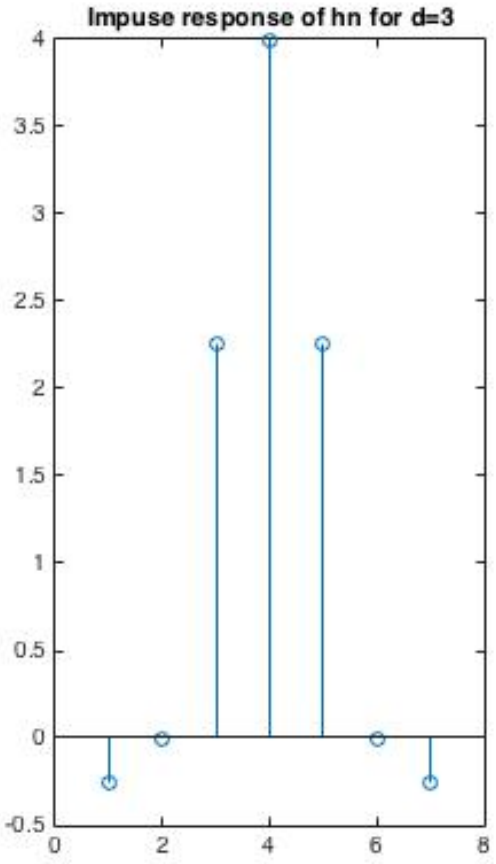


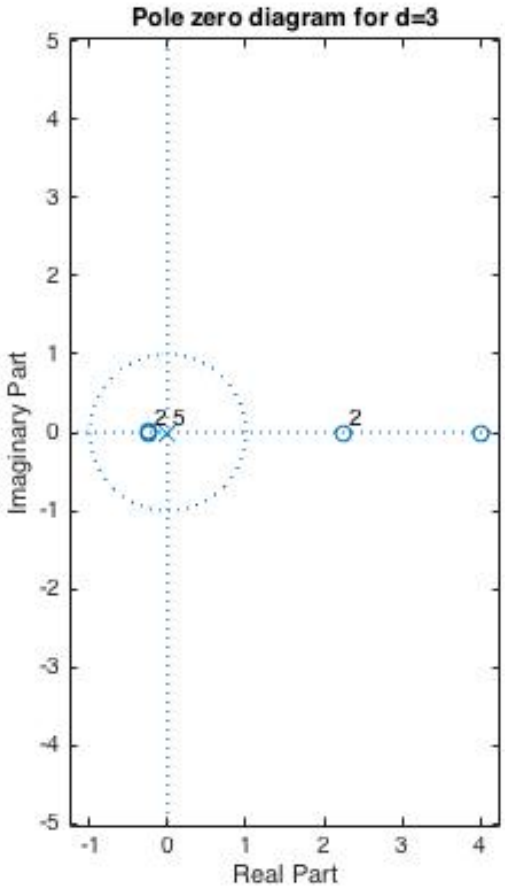


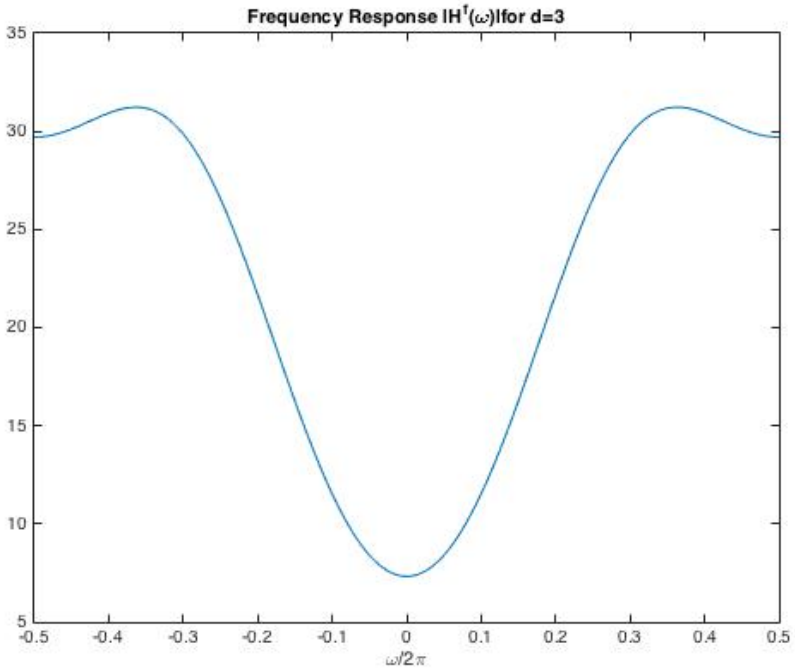
H(n) is half band

for d=3

```
q=[-1/4 1 -1/4]
```

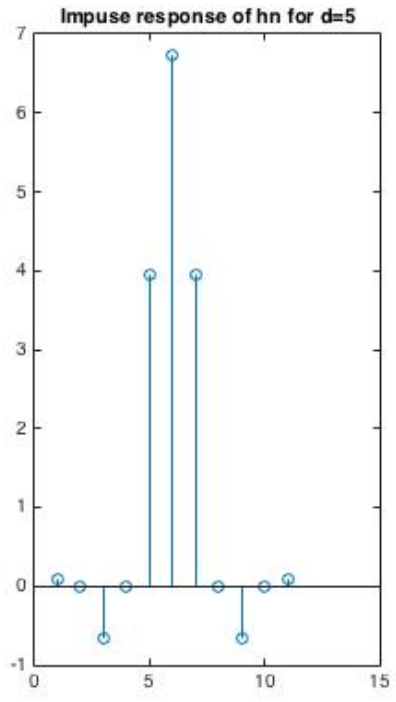


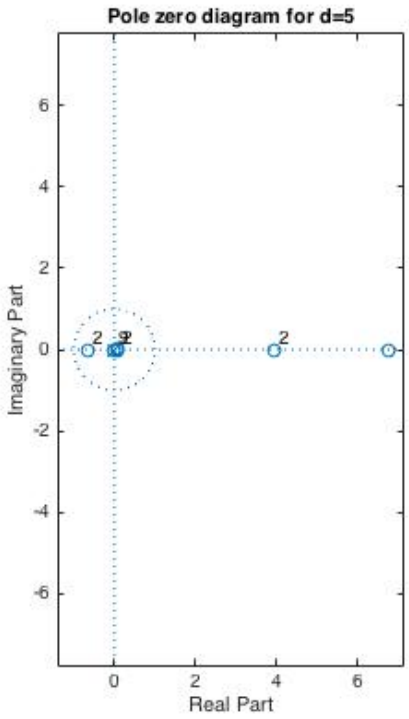


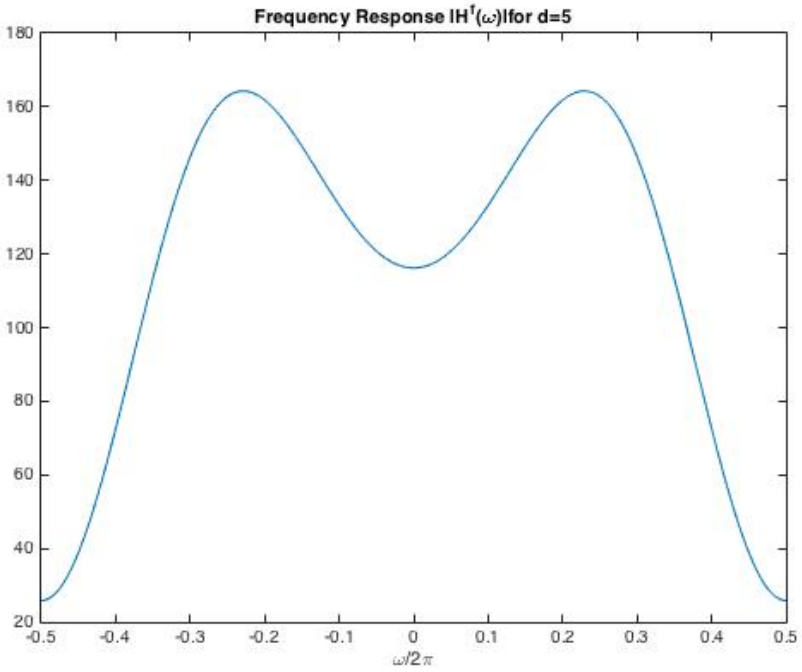


for d=5

```
q=[3/38 -9/19 1 -9/19 3/38]
```







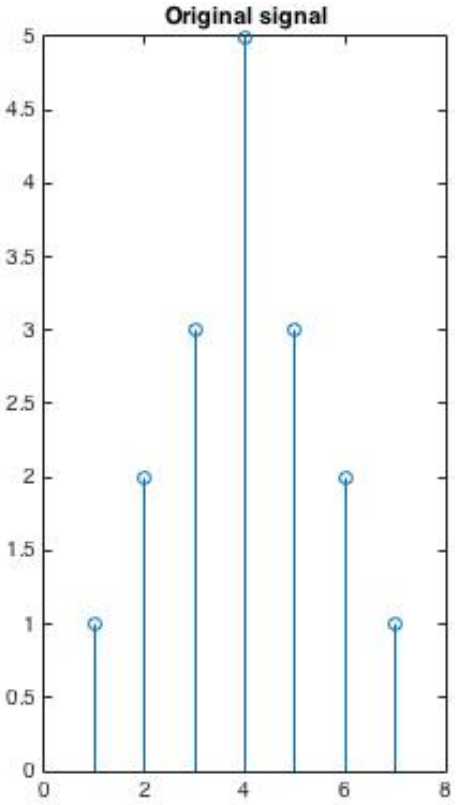
h(n) obtained is a half band filter and satisfies all the constraint laid down in the design of filter.

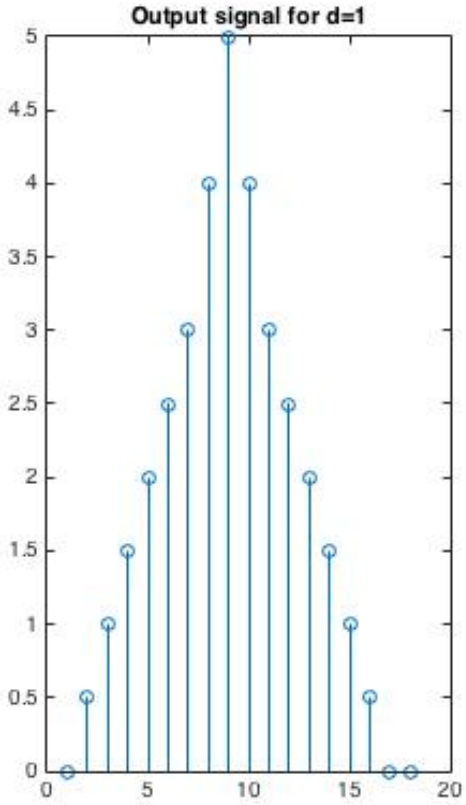
Question 3C

C) Perform interpolation (by factor 2) using the half-band filters from (B). Verify that the values of the input signal are not changed by the process. Use the signal provided on the web: bumps.txt, pwsmooth.txt, skyline.txt. Comment on your results.

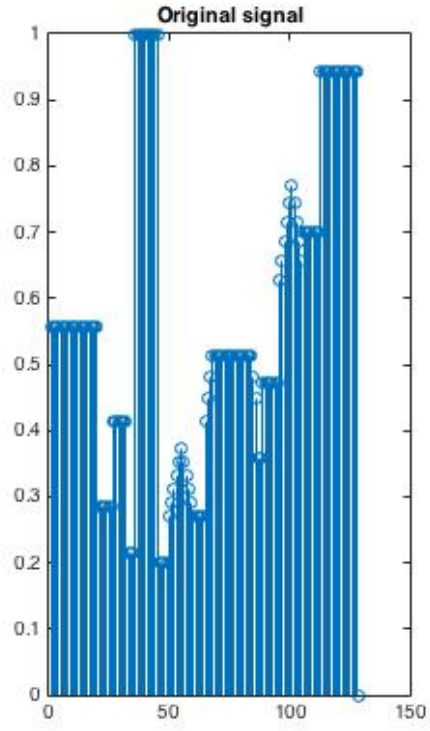
```
clc;clear all; close all;
% for d=1
d=1;
% q=[0.5 0]
q=[-1/4 1 1/4];
% q=[3/38 -9/19 1 -9/19 3/38]

p=[1 1];
p1=[1 1];
for i=1:d
    p=conv(p,p1);
end
hn=conv(q,p)

% Input signal
% x=[1 2 3 5 3 2 1];

x=dlmread('skyline.txt');
% Performing interpolation by 2
l=length(x);
if mod(length(x),2)==0
  x(l+1)=0;
end
l=length(x)-1;
j=l+1;
for i=l/2:-1:1
    x1(j)=0;
    x1(j-1)=x(i);
    j=j-2;
end

j=l+2;
for i=l/2+1:l+1
    x1(j)=x(i);
    x1(j+1)=0;
    j=j+2;
end
% Interpolation figure
figure,
subplot(1,2,1),stem(x);title('Original signal');
subplot(1,2,2),stem(x1);title('Interpolation by 2 upsampling')

% Output
yn=conv(x1,hn);
figure,
subplot(1,2,1),stem(x);title('Original signal');
subplot(1,2,2),stem(yn);title(['Output signal for d='num2str(d)]);
```

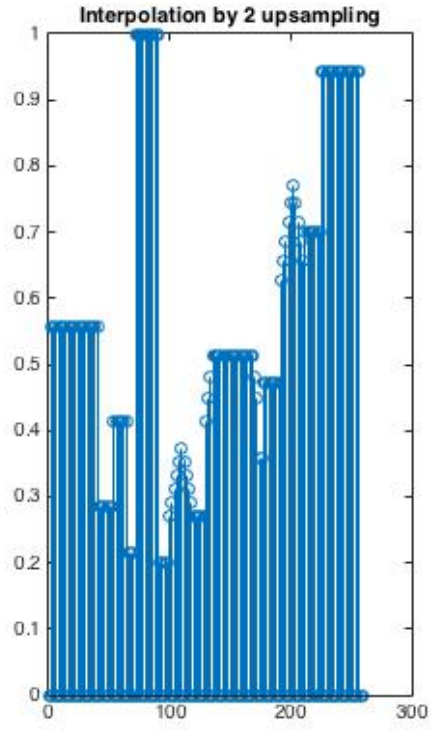
First I took my own signal as input
Here, is the result

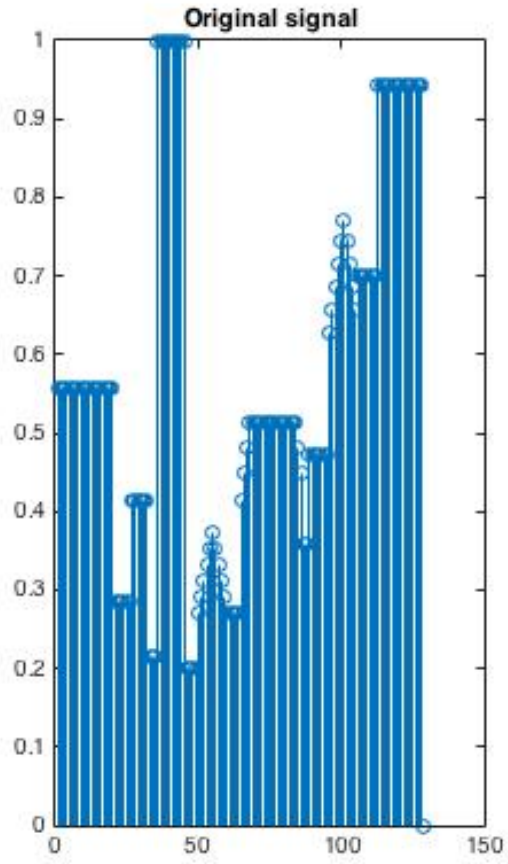


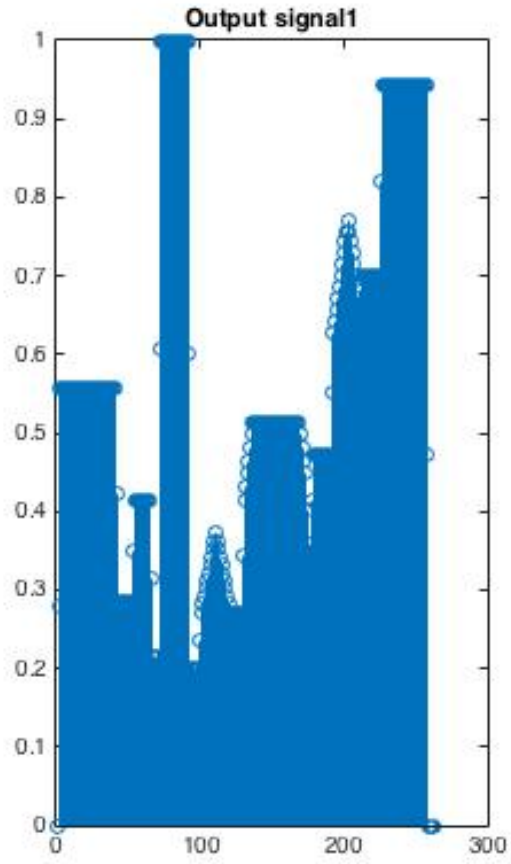


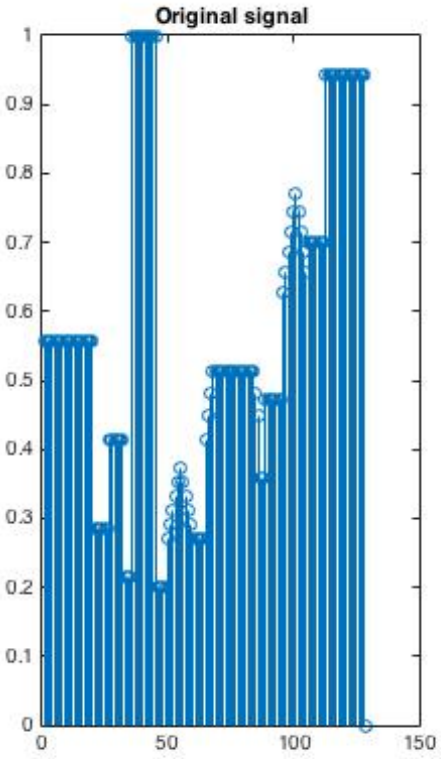
For skyline input,
For
d=1,3, 5 respectively

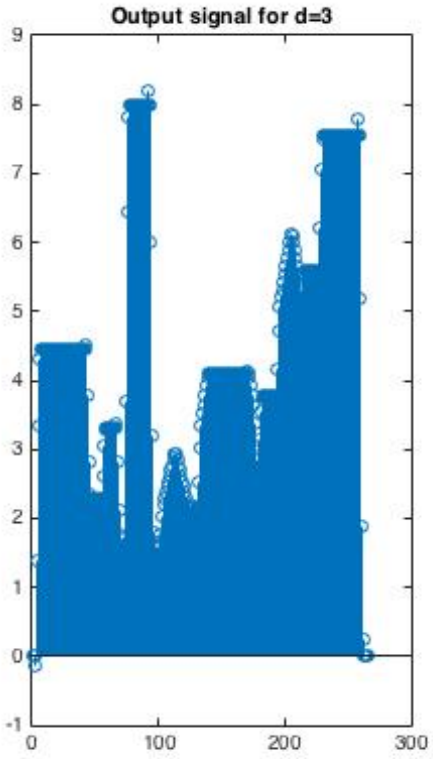


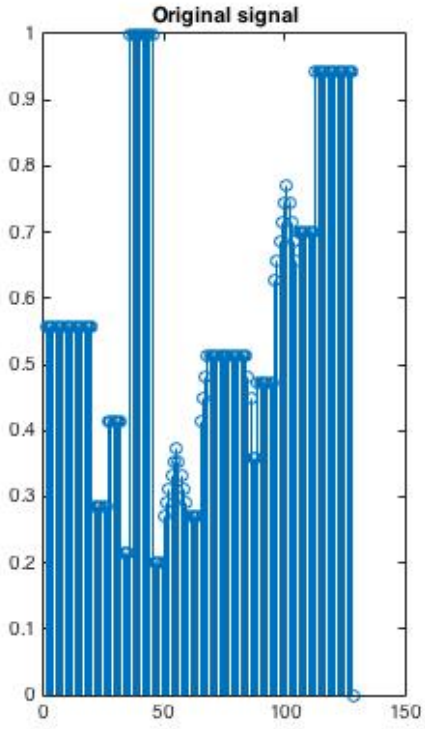


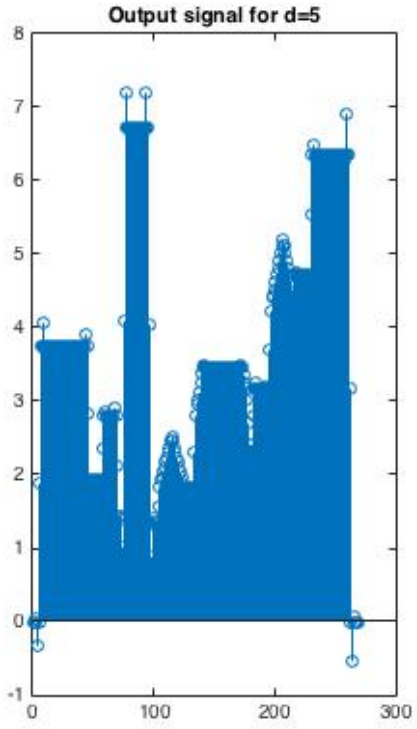

Original signal
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150


Output signal1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
100
200
300


Original signal
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
50
100
150


Output signal for d=3
-1
0
1
2
3
4
5
6
7
8
9
0
100
200
300





Here, first we performed the upsampling by a factor of 2 and then did the interpolation by the designed filter for d=1 , 3 , 5 The result obtained is perfect for d=1. However,The result obtained is modified by some magnitude uniformly for d=3 and 5 after convolution which is not a desired property.