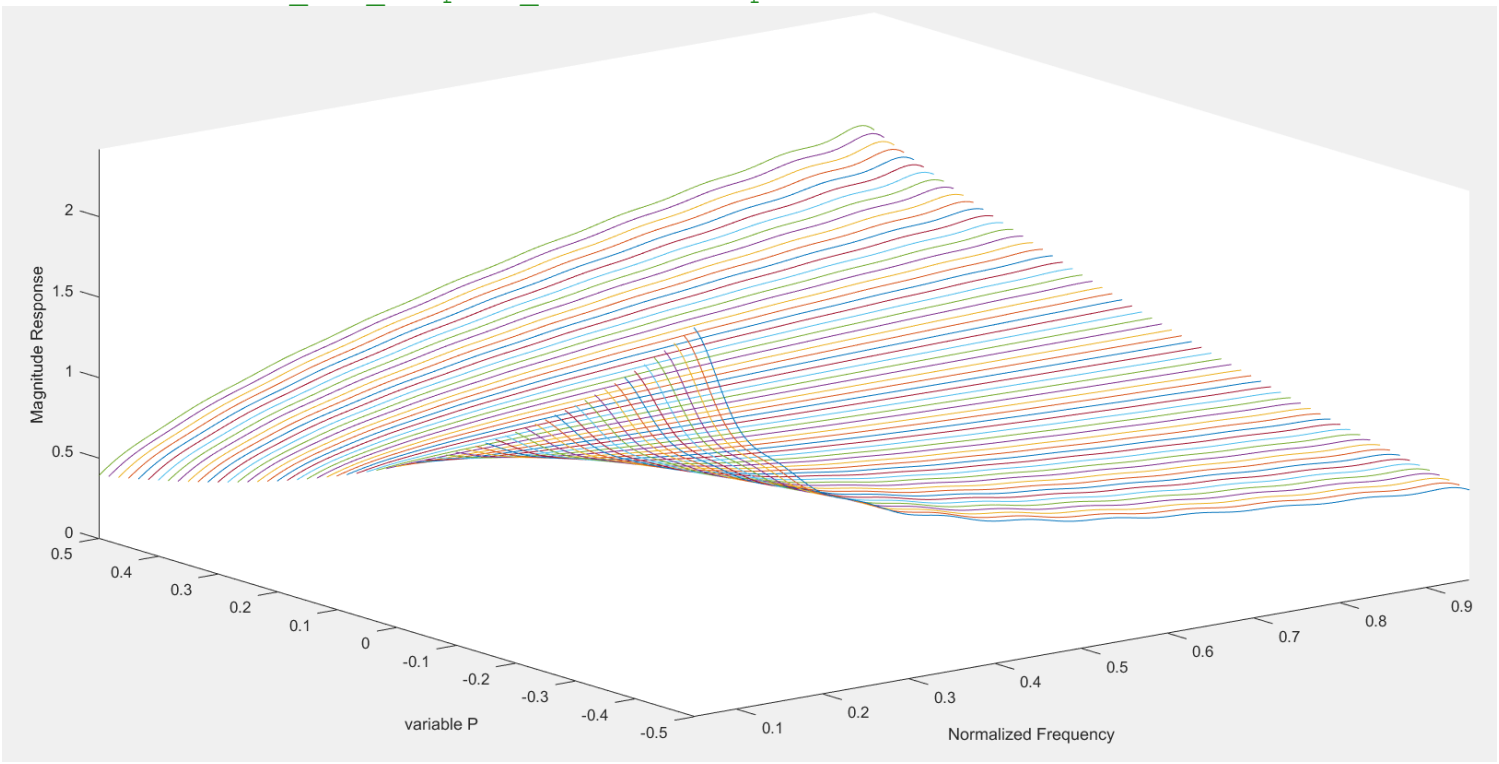
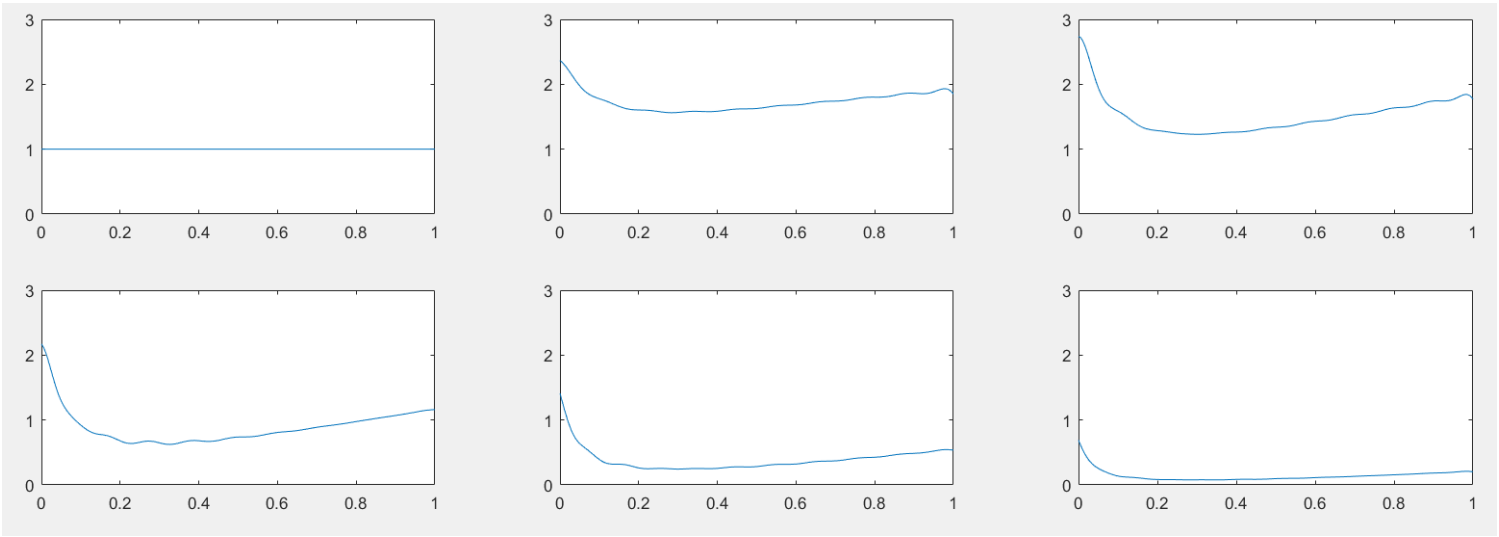
```
%                          DSP_Project_6
%
% Design of Variable_Fractional_Order_FIR_Differintegrators
_Example_1
%
% example 1. (N,  M,  w1,    w2,   p1,   p2)
%          = (40, 5, 0.05pi, 0.95pi, -0.5, +0.5)
clear all;   % clear workspace
clc;         % clear command window
N=40;
M=5;
w1=0.05*pi;
w2=0.95*pi;
p1=-0.5;
p2=0.5;
pointw=200;
pointp=60;
%
%
NH=N/2;
nma=(NH+1)*(M+1);
nmb=NH*(M+1);
deltaw=(w2-w1)/pointw;
deltap=(p2-p1)/pointp;
point=(pointw+1)*(pointp+1);
%
%
ra=zeros(nma,1);
Qa=zeros(nma,nma);
for ip=0:pointp
    p=p1+ip*deltap;
    for iw=0:pointw
        w=w1+iw*deltaw;
        c=zeros(nma,1);
        for i=0:nma-1
            n=mod(i,NH+1);
            m=floor(i/(NH+1));
            c(i+1)=p^m*cos(n*w);
        end
    ra=ra-2*w^p*cos(p*pi/2)*c;
    Qa=Qa+c*c';
    end
end
ra=ra*(w2-w1)*(p2-p1)/point;
Qa=Qa*(w2-w1)*(p2-p1)/point;
a=-0.5*inv(Qa)*ra;
```

```
rb=zeros(nmb,1);
Qb=zeros(nmb,nmb);
for ip=0:pointp
    p=p1+ip*deltap;
    for iw=0:pointw
        w=w1+iw*deltaw;
        s=zeros(nmb,1);
        for i=0:nmb-1
            n=mod(i,NH)+1;
            m=floor(i/NH);
            s(i+1)=p^m*sin(n*w);
        end
    rb=rb-2*w^p*sin(p*pi/2)*s;
    Qb=Qb+s*s';
    end
end
rb=rb*(w2-w1)*(p2-p1)/point;
Qb=Qb*(w2-w1)*(p2-p1)/point;
b=-0.5*inv(Qb)*rb;
%
%
a2=reshape(a,NH+1,M+1); % even part
he=zeros(N+1,M+1);
he(NH+1,:)=a2(1,:);
he(1:NH,:)=0.5*a2(NH+1:-1:2,:);
he(NH+2:N+1,:)=0.5*a2(2:NH+1,:);
%
b2=reshape(b,NH,M+1); % odd part
ho=zeros(N+1,M+1);
ho(1:NH,:)=0.5*b2(NH:-1:1,:);
ho(NH+2:N+1,:)=-0.5*b2;
%
%
h=he+ho;
%
MR=zeros(pointw+1,pointp+1);
for ip=0:pointp;
    p=p1+ip*deltap;
    hnp=h(:,1);
    for im=1:M
        hnp=hnp+h(:,im+1)*p^im;
    end
    MR(:,ip+1)=abs(freqz(hnp,1,w1:deltaw:w2));
end
%
XX=zeros(pointw+1,pointp+1);
YY=zeros(pointw+1,pointp+1);
```

```
for ip=0:pointp
    XX(:,ip+1)=(w1:deltaw:w2)/pi';
end
for iw=0:pointw
    YY(iw+1,:)=p1:deltap:p2;
end
%
plot3(XX,YY,MR);
axis([w1/pi,w2/pi,p1,p2,0,max(max(MR))]);
xlabel('Normalized Frequency');
ylabel('variable P');
zlabel('Magnitude Response');
pause;
%
for im=0:M
    MRs=abs(freqz(h(:,im+1),1,w1:deltaw:w2));
    subplot(3,3,im+1);
    plot(0:1/200:1,MRs);
    axis([0,1,0,3]);
end
```

```
% Variable_FIR_Lowpass_Filter Example 1
```

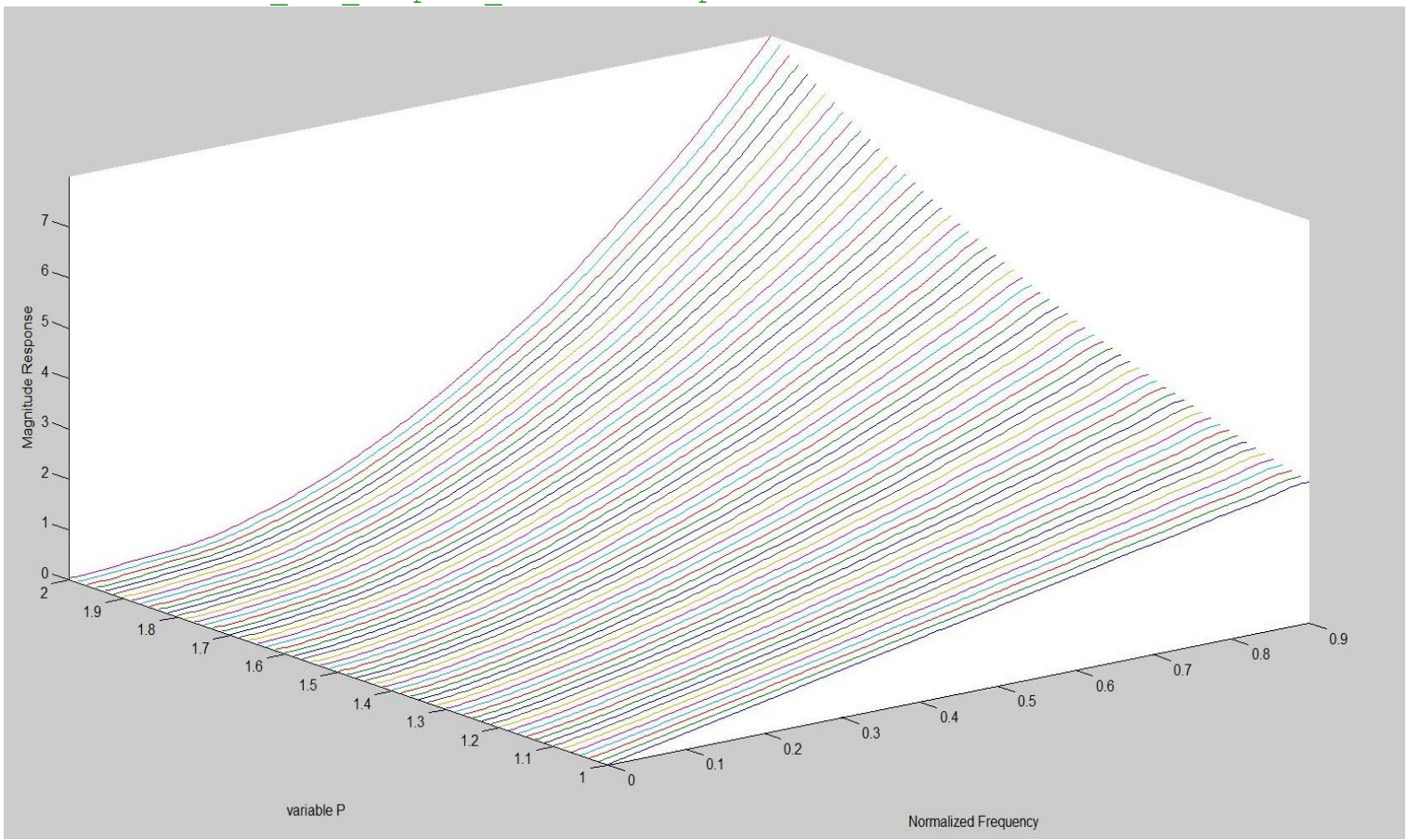


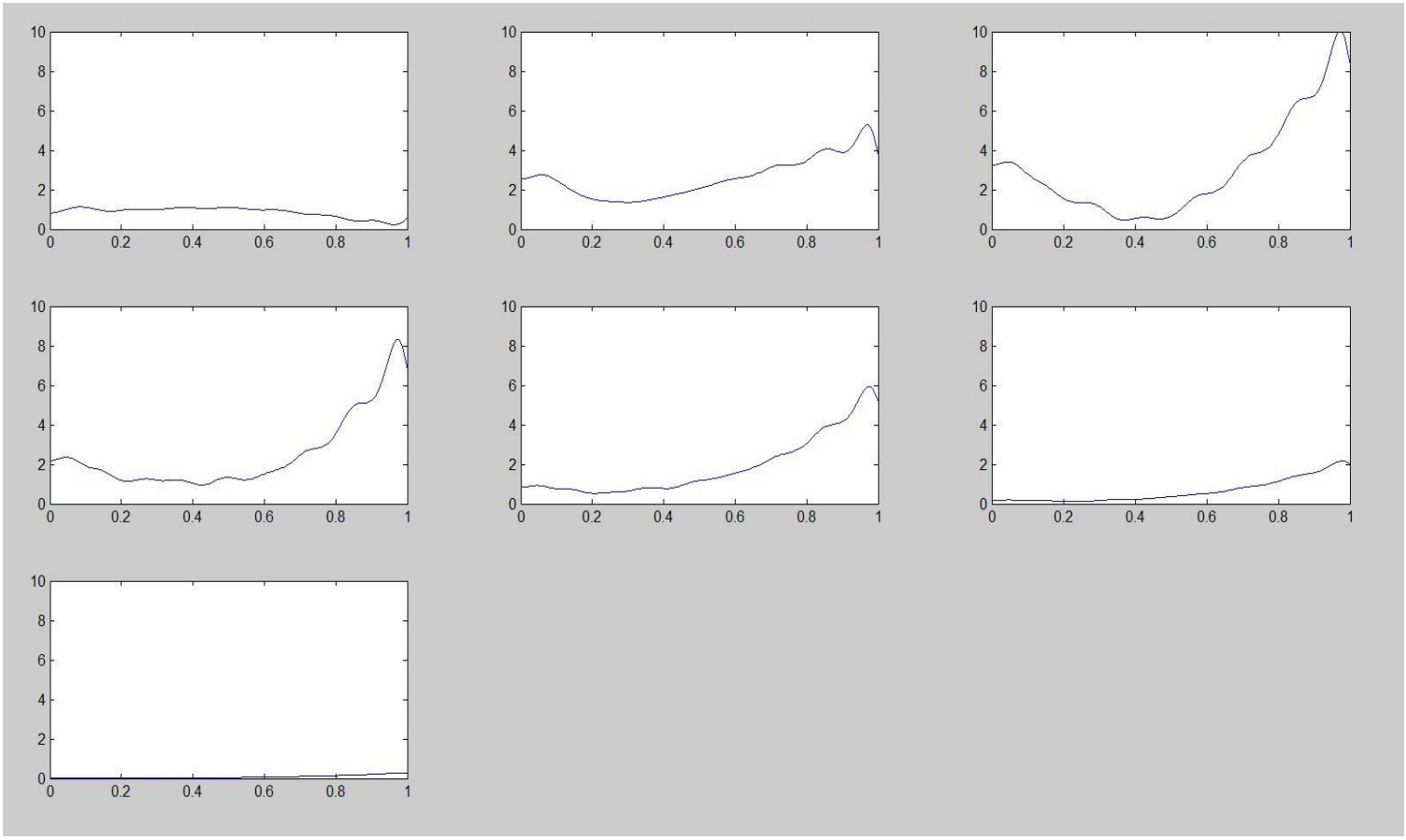


```
%
% Design of Variable_FractionalOrder_FIR_Differintegrators
_Example_2
%
% example 2. (N,  M, w1,  w2,   p1, p2)
%          = (30, 6, 0,  0.9pi, 1,  2)
clear all;   % clear workspace
clc;         % clear command window
N=30;
M=6;
w1=0;
w2=0.9*pi;
p1=1;
p2=2;
pointw=200;
pointp=60;
%
%
NH=N/2;
nma=(NH+1)*(M+1);
nmb=NH*(M+1);
deltaw=(w2-w1)/pointw;
deltap=(p2-p1)/pointp;
point=(pointw+1)*(pointp+1);
%
%
ra=zeros(nma,1);
Qa=zeros(nma,nma);
for ip=0:pointp
    p=p1+ip*deltap;
    for iw=0:pointw
        w=w1+iw*deltaw;
        c=zeros(nma,1);
        for i=0:nma-1
            n=mod(i,NH+1);
            m=floor(i/(NH+1));
            c(i+1)=p^m*cos(n*w);
        end
    ra=ra-2*w^p*cos(p*pi/2)*c;
    Qa=Qa+c*c';
    end
end
ra=ra*(w2-w1)*(p2-p1)/point;
Qa=Qa*(w2-w1)*(p2-p1)/point;
a=-0.5*inv(Qa)*ra;

rb=zeros(nmb,1);
```

```
Qb=zeros(nmb,nmb);
for ip=0:pointp
    p=p1+ip*deltap;
    for iw=0:pointw
        w=w1+iw*deltaw;
        s=zeros(nmb,1);
        for i=0:nmb-1
            n=mod(i,NH)+1;
            m=floor(i/NH);
            s(i+1)=p^m*sin(n*w);
        end
    rb=rb-2*w^p*sin(p*pi/2)*s;
    Qb=Qb+s*s';
    end
end
rb=rb*(w2-w1)*(p2-p1)/point;
Qb=Qb*(w2-w1)*(p2-p1)/point;
b=-0.5*inv(Qb)*rb;
%
%
a2=reshape(a,NH+1,M+1); % even part
he=zeros(N+1,M+1);
he(NH+1,:)=a2(1,:);
he(1:NH,:)=0.5*a2(NH+1:-1:2,:);
he(NH+2:N+1,:)=0.5*a2(2:NH+1,:);
%
b2=reshape(b,NH,M+1); % odd part
ho=zeros(N+1,M+1);
ho(1:NH,:)=0.5*b2(NH:-1:1,:);
ho(NH+2:N+1,:)=-0.5*b2;
%
%
h=he+ho;
%
MR=zeros(pointw+1,pointp+1);
for ip=0:pointp;
    p=p1+ip*deltap;
    hnp=h(:,1);
    for im=1:M
        hnp=hnp+h(:,im+1)*p^im;
    end
    MR(:,ip+1)=abs(freqz(hnp,1,w1:deltaw:w2));
end
%
XX=zeros(pointw+1,pointp+1);
YY=zeros(pointw+1,pointp+1);
for ip=0:pointp
```

```
    XX(:,ip+1)=(w1:deltaw:w2)/pi';
end
for iw=0:pointw
    YY(iw+1,:)=p1:deltap:p2;
end
%
plot3(XX,YY,MR);
axis([w1/pi,w2/pi,p1,p2,0,max(max(MR))]);
xlabel('Normalized Frequency');
ylabel('variable P');
zlabel('Magnitude Response');
pause;
%
for im=0:M
    MRs=abs(freqz(h(:,im+1),1,w1:deltaw:w2));
    subplot(3,3,im+1);
    plot(0:1/200:1,MRs);
    axis([0,1,0,max(MRs)]);
end

% Variable_FIR_Lowpass_Filter Example 2
```

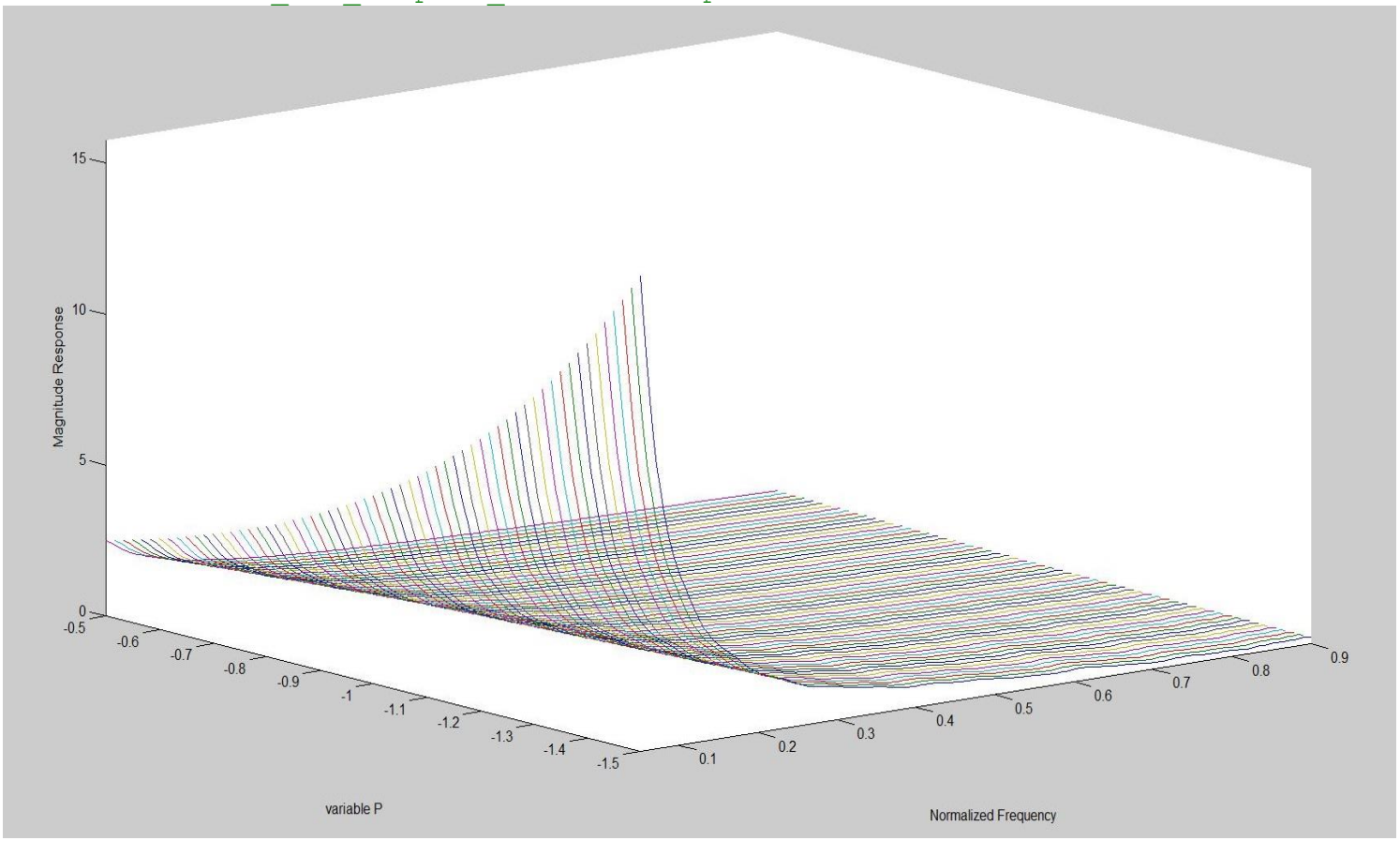


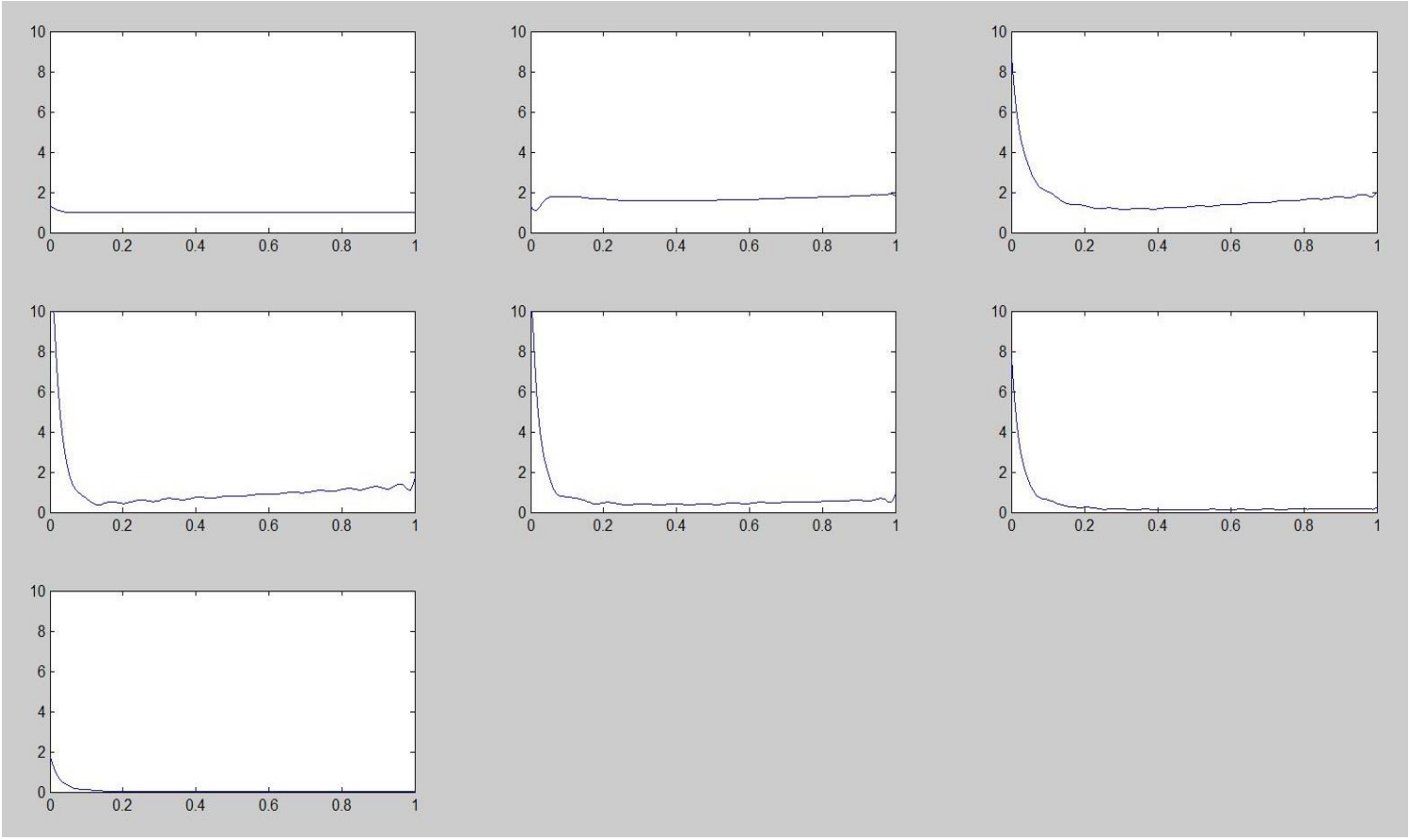

10
8
6
4
2
0
0 0.2 0.4 0.6 0.8 1

```
%
% Design of Variable_FractionalOrder_FIR_Differintegrators
_Example_3
%
% example 3. (N,  M,  w1,     w2,    p1,   p2)
%          = (60, 6, 0.05pi,  0.9pi, -1.5,  -0.5)
clear all;   % clear workspace
clc;         % clear command window
N=60;
M=6;
w1=0.05*pi;
w2=0.9*pi;
p1=-1.5;
p2=-0.5;
pointw=200;
pointp=60;
%
%
NH=N/2;
nma=(NH+1)*(M+1);
nmb=NH*(M+1);
deltaw=(w2-w1)/pointw;
deltap=(p2-p1)/pointp;
point=(pointw+1)*(pointp+1);
%
%
ra=zeros(nma,1);
Qa=zeros(nma,nma);
for ip=0:pointp
    p=p1+ip*deltap;
    for iw=0:pointw
        w=w1+iw*deltaw;
        c=zeros(nma,1);
        for i=0:nma-1
            n=mod(i,NH+1);
            m=floor(i/(NH+1));
            c(i+1)=p^m*cos(n*w);
        end
    ra=ra-2*w^p*cos(p*pi/2)*c;
    Qa=Qa+c*c';
    end
end
ra=ra*(w2-w1)*(p2-p1)/point;
Qa=Qa*(w2-w1)*(p2-p1)/point;
a=-0.5*inv(Qa)*ra;

rb=zeros(nmb,1);
```

```
Qb=zeros(nmb,nmb);
for ip=0:pointp
    p=p1+ip*deltap;
    for iw=0:pointw
        w=w1+iw*deltaw;
        s=zeros(nmb,1);
        for i=0:nmb-1
            n=mod(i,NH)+1;
            m=floor(i/NH);
            s(i+1)=p^m*sin(n*w);
        end
    rb=rb-2*w^p*sin(p*pi/2)*s;
    Qb=Qb+s*s';
    end
end
rb=rb*(w2-w1)*(p2-p1)/point;
Qb=Qb*(w2-w1)*(p2-p1)/point;
b=-0.5*inv(Qb)*rb;
%
%
a2=reshape(a,NH+1,M+1); % even part
he=zeros(N+1,M+1);
he(NH+1,:)=a2(1,:);
he(1:NH,:)=0.5*a2(NH+1:-1:2,:);
he(NH+2:N+1,:)=0.5*a2(2:NH+1,:);
%
b2=reshape(b,NH,M+1); % odd part
ho=zeros(N+1,M+1);
ho(1:NH,:)=0.5*b2(NH:-1:1,:);
ho(NH+2:N+1,:)=-0.5*b2;
%
%
h=he+ho;
%
MR=zeros(pointw+1,pointp+1);
for ip=0:pointp;
    p=p1+ip*deltap;
    hnp=h(:,1);
    for im=1:M
        hnp=hnp+h(:,im+1)*p^im;
    end
    MR(:,ip+1)=abs(freqz(hnp,1,w1:deltaw:w2));
end
%
XX=zeros(pointw+1,pointp+1);
YY=zeros(pointw+1,pointp+1);
for ip=0:pointp
```

```
    XX(:,ip+1)=(w1:deltaw:w2)/pi';
end
for iw=0:pointw
    YY(iw+1,:)=p1:deltap:p2;
end
%
plot3(XX,YY,MR);
axis([w1/pi,w2/pi,p1,p2,0,max(max(MR))]);
xlabel('Normalized Frequency');
ylabel('variable P');
zlabel('Magnitude Response');
pause;
%
for im=0:M
    MRs=abs(freqz(h(:,im+1),1,w1:deltaw:w2));
    subplot(3,3,im+1);
    plot(0:1/200:1,MRs);
    axis([0,1,0,10]);
end

% Variable_FIR_Lowpass_Filter Example 3
```




10
8
6
4
2
0
0 0.2 0.4 0.6 0.8 1