Print the networked system

```
clear all
close all
clc
load jPaperDataSimulation.mat

% Diagonal matrices out of Network Matrices: A,B,C,D,E,F,G,H,J,Q,S,R
% (1 if true, -1 % if zero and 0 if false)
% diags = [0,1,1,-1,0,1,1,1,1]; % respectively for
for i = 1:1:length(network.subsystems)
    format = '%.3f';
    format2 = '%.3f';
    strTemp = "\dot{x}_"+num2str(i)+" = ";
    disp(['A_ij Matrices for i = ',num2str(i)])
    for j = 1:1:length(network.subsystems)
%         disp(['Agent i=',num2str(i),' connect to agent j=',num2str(j)])
        network.subsystems(i).A{j};
        A_ij = network.subsystems(i).A{j}';
        A_ijAll = A_ij(:);
        if all(A_ijAll==0)
            continue
        end
        strTemp = strTemp + "\bm{ ";
        strTemp = strTemp + num2str(A_ijAll(1),format) + " & " + num2str(A_ijAll(2),format) + "
        strTemp = strTemp + "} x_"+num2str(j) + " + ";
%         disp(strTemp)
    end

    disp(['B_ii Matrices for i = ',num2str(i)])
    B_ii = network.subsystems(i).B{i}(:);
    strTemp = strTemp + "\bm{" + num2str(B_ii(1),format) + " \\ " + num2str(B_ii(2),format) + "
%     disp(strTemp)

    disp(['E_ij Matrices for i = ',num2str(i)])
    for j = 1:1:length(network.subsystems)
%         disp(['Agent i=',num2str(i),' connect to agent j=',num2str(j)])
        E_ij = network.subsystems(i).E{j};
        if all(E_ij==0)
            continue
        end
        strTemp = strTemp + "\bm{ " + num2str(E_ij(1),format2) + " \\ " + num2str(E_ij(2),forma
    end
    disp(strTemp)


    strTemp = "y_"+num2str(i)+" = ";
    disp(['C_ii Matrices for i = ',num2str(i)])
    C_ii = network.subsystems(i).C{i}(:);
    strTemp = strTemp + "\bm{" + num2str(C_ii(1),format) + " & " + num2str(C_ii(2),format) + "
%     disp(strTemp)

    disp(['F_ii Matrices for i = ',num2str(i)])
    F_ii = network.subsystems(i).F{i}(:);
```

```
    strTemp = strTemp + "\bm{" + num2str(F_ii(1),format2) + "} w_"+num2str(i);
    disp(strTemp)


    strTemp = "z_"+num2str(i)+" = ";
    disp(['G_ii Matrices for i = ',num2str(i)])
    G_ii = network.subsystems(i).G{i}(:);
    strTemp = strTemp + "\bm{" + num2str(G_ii(1),format) + " & " + num2str(G_ii(2),format) + "
%     disp(strTemp)

    disp(['H_ii Matrices for i = ',num2str(i)])
    H_ii = network.subsystems(i).H{i}(:);
    strTemp = strTemp + "\bm{" + num2str(H_ii(1),format) + "} u_"+num2str(i)+" + ";
%     disp(strTemp)

    disp(['J_ii Matrices for i = ',num2str(i)])
    J_ii = network.subsystems(i).J{i}(:);
    strTemp = strTemp + "\bm{" + num2str(J_ii(1),format2) + "} w_"+num2str(i);
    disp(strTemp)
end
```

```
A_ij Matrices for i = 1
B_ii Matrices for i = 1
E_ij Matrices for i = 1
\dot{x}_1 = \bm{ 0.198 & 3.412 \\ -3.412 & 0.198} x_1 + \bm{ -0.114 & -0.038 \\ -0.038 & -0.073} x_2 + \bm{ -0.060 &
C_ii Matrices for i = 1
F_ii Matrices for i = 1
y_1 = \bm{1.114 & -2.429} x_1 + \bm{0.000} w_1
G_ii Matrices for i = 1
H_ii Matrices for i = 1
J_ii Matrices for i = 1
z_1 = \bm{1.000 & 1.000} x_1 + \bm{1.000} u_1 + \bm{1.000} w_1
A_ij Matrices for i = 2
B_ii Matrices for i = 2
E_ij Matrices for i = 2
\dot{x}_2 = \bm{ -0.000 & -0.001 \\ -0.001 & -0.194} x_1 + \bm{ 1.547 & 3.164 \\ -3.164 & 1.547} x_2 + \bm{ -0.258 &
C_ii Matrices for i = 2
F_ii Matrices for i = 2
y_2 = \bm{0.000 & 1.062} x_2 + \bm{0.002} w_2
G_ii Matrices for i = 2
H_ii Matrices for i = 2
J_ii Matrices for i = 2
z_2 = \bm{1.000 & 1.000} x_2 + \bm{1.000} u_2 + \bm{1.000} w_2
A_ij Matrices for i = 3
B_ii Matrices for i = 3
E_ij Matrices for i = 3
\dot{x}_3 = \bm{ -0.232 & -0.070 \\ -0.070 & -0.158} x_1 + \bm{ -0.096 & -0.062 \\ -0.062 & -0.085} x_2 + \bm{ 10.79
C_ii Matrices for i = 3
F_ii Matrices for i = 3
y_3 = \bm{1.052 & 0.759} x_3 + \bm{-0.011} w_3
G_ii Matrices for i = 3
H_ii Matrices for i = 3
J_ii Matrices for i = 3
z_3 = \bm{1.000 & 1.000} x_3 + \bm{1.000} u_3 + \bm{1.000} w_3
A_ij Matrices for i = 4
B_ii Matrices for i = 4
E_ij Matrices for i = 4
\dot{x}_4 = \bm{ -0.180 & -0.066 \\ -0.066 & -0.078} x_1 + \bm{ 1.669 & 2.302 \\ 2.302 & 3.175} x_4 + \bm{0.000 \\ 0
C_ii Matrices for i = 4
F_ii Matrices for i = 4
```

```
y_4 = \bm{0.629 & 0.000} x_4 + \bm{0.000} w_4
G_ii Matrices for i = 4
H_ii Matrices for i = 4
J_ii Matrices for i = 4
z_4 = \bm{1.000 & 1.000} x_4 + \bm{1.000} u_4 + \bm{1.000} w_4
A_ij Matrices for i = 5
B_ii Matrices for i = 5
E_ij Matrices for i = 5
\dot{x}_5 = \bm{ -0.059 & 0.033 \\ 0.033 & -0.057} x_4 + \bm{ 0.058 & 0.250 \\ 0.250 & 1.074} x_5 + \bm{0.870 \\ -1.
C_ii Matrices for i = 5
F_ii Matrices for i = 5
y_5 = \bm{-0.552 & -0.750} x_5 + \bm{0.000} w_5
G_ii Matrices for i = 5
H_ii Matrices for i = 5
J_ii Matrices for i = 5
z_5 = \bm{1.000 & 1.000} x_5 + \bm{1.000} u_5 + \bm{1.000} w_5
```

```
% Decentralized FSF Stabilizing Controller coeeffs
height = 1; width = 2;
keyString = "K_{"
```

```
keyString =
"K_{"
```

```
KMat = KStabD
```

```
KMat = 5×10
   -0.2957   -1.5228   -0.1729    0.5740         0         0   -0.9729    0.1139 ···
   -0.1682   -0.0427    5.3692   -3.9162         0         0   -0.2336    0.0405
   -0.0831   -0.1179   -0.0571   -0.0674   32.4494    5.4294    0.2480   -0.1095
    1.0232    0.2787         0         0         0         0  -12.9739   -8.0814
         0         0         0         0         0         0    0.0348   -0.0390
```

```
for i = 1:1:length(network.subsystems)
    tempStr = keyString+num2str(i)+" =&\ \left\{";
    for j = 1:1:(i-1)
        K_ij = KMat(height*(i-1)+1:height*i,width*(j-1)+1:width*j);
        K_ji = KMat(height*(j-1)+1:height*j,width*(i-1)+1:width*i);
        if any(K_ij~=0)
            tempStr = tempStr + keyString+num2str(i)+num2str(j)+"}=\bm{"+num2str(K_ij(1),format
        end
        if any(K_ji~=0)
            tempStr = tempStr + keyString+num2str(j)+num2str(i)+"}=\bm{"+num2str(K_ji(1),format
        end
    end
    K_ii = KMat(height*(i-1)+1:height*i,width*(i-1)+1:width*i);
    tempStr = tempStr + keyString+num2str(i)+num2str(i)+"}=\bm{"+num2str(K_ii(1),format)+" & "+
    disp(tempStr)
end
```

```
K_{1 =&\ \left\{K_{11}=\bm{-0.296 & -1.523}\right\},\\
K_{2 =&\ \left\{K_{21}=\bm{-0.168 & -0.043}, K_{12}=\bm{-0.173 & 0.574}, K_{22}=\bm{5.369 & -3.916}\right\},\\
K_{3 =&\ \left\{K_{31}=\bm{-0.083 & -0.118}, K_{32}=\bm{-0.057 & -0.067}, K_{33}=\bm{32.449 & 5.429}\right\},\\
K_{4 =&\ \left\{K_{41}=\bm{1.023 & 0.279}, K_{14}=\bm{-0.973 & 0.114}, K_{24}=\bm{-0.234 & 0.041}, K_{34}=\bm{0.248
K_{5 =&\ \left\{K_{54}=\bm{0.035 & -0.039}, K_{55}=\bm{1.753 & 2.803}\right\},\\
```

```
% Decentralized Observer gains
height = 2; width = 1;
keyString = "L_{"
```

```
keyString =
"L_{"
```

```
KMat = LStabD
```

```
KMat = 10×5
    0.3060   -0.0423         0   -0.6400         0
   -0.4270   -0.2068         0    1.3951         0
    0.0598   -3.4029         0   -0.4094         0
   -0.0077    4.5958         0   -0.0123         0
   -0.0125   -0.0587   12.2189   -0.1169         0
    0.0430   -0.0804    3.6156    0.6103         0
   -0.5768         0         0   35.6019         0
   -1.5909         0         0   97.0478         0
         0         0         0   -0.0942    0.5888
         0         0         0    0.0532   -3.5854
```

```
for i = 1:1:length(network.subsystems)
    tempStr = keyString+num2str(i)+"} =&\ \left\{";
    for j = 1:1:(i-1)
        K_ij = KMat(height*(i-1)+1:height*i,width*(j-1)+1:width*j);
        K_ji = KMat(height*(j-1)+1:height*j,width*(i-1)+1:width*i);
        if any(K_ij~=0)
            tempStr = tempStr + keyString+num2str(i)+num2str(j)+"}=\bm{"+num2str(K_ij(1),format
        end
        if any(K_ji~=0)
            tempStr = tempStr + keyString+num2str(j)+num2str(i)+"}=\bm{"+num2str(K_ji(1),format
        end
    end
    K_ii = KMat(height*(i-1)+1:height*i,width*(i-1)+1:width*i);
    tempStr = tempStr + keyString+num2str(i)+num2str(i)+"}=\bm{"+num2str(K_ii(1),format)+" \\ "
    disp(tempStr)
end
```

```
L_{1} =&\ \left\{L_{11}=\bm{0.306 \\ -0.427}\right\},\\
L_{2} =&\ \left\{L_{21}=\bm{0.060 \\ -0.008}, L_{12}=\bm{-0.042 \\ -0.207}, L_{22}=\bm{-3.403 \\ 4.596}\right\},\\
L_{3} =&\ \left\{L_{31}=\bm{-0.012 \\ 0.043}, L_{32}=\bm{-0.059 \\ -0.080}, L_{33}=\bm{12.219 \\ 3.616}\right\},\\
L_{4} =&\ \left\{L_{41}=\bm{-0.577 \\ -1.591}, L_{14}=\bm{-0.640 \\ 1.395}, L_{24}=\bm{-0.409 \\ -0.012}, L_{34}=\bm
L_{5} =&\ \left\{L_{54}=\bm{-0.094 \\ 0.053}, L_{55}=\bm{0.589 \\ -3.585}\right\},\\
```

```
% Decentralized DOF A_c
% Decentralized Observer gains
height = 2; width = 2;
keyString = "A_{c,"
```

```
keyString =
"A_{c,"
```

```
KMat = AcStabD
```

```
KMat = 10×10
   -2.0074    3.7395   -0.0794   -0.3186         0         0    0.1751   -1.9334 ···
   -8.6968    3.8658    0.0419   -0.8674         0         0    0.0099   -2.9209
    0.1424   -0.1982   -4.7429  -16.0326         0         0    0.2228   -3.0944
```

```
    0.0185    0.1936    3.7289   -1.2250         0         0   -0.0410   -0.5634
    0.0567    0.1189   -0.0011   -0.0028   45.3574 -183.6804    0.0008   -0.0309
   -0.0591    0.0419   -0.0563   -0.1310   13.8408  -62.3236    0.0548   -2.5776
   -2.7966   -0.2254         0         0         0         0   -0.3320  151.6853
    0.4269    0.0869         0         0         0         0   -1.4208  -14.2647
   -0.1472    0.0439   -0.0818   -0.2423    0.1112   -0.3392    0.0003   -0.0123
    0.0029   -0.0272   -0.0121    0.0211   -0.0192    0.0090    0.0001   -0.0033
```

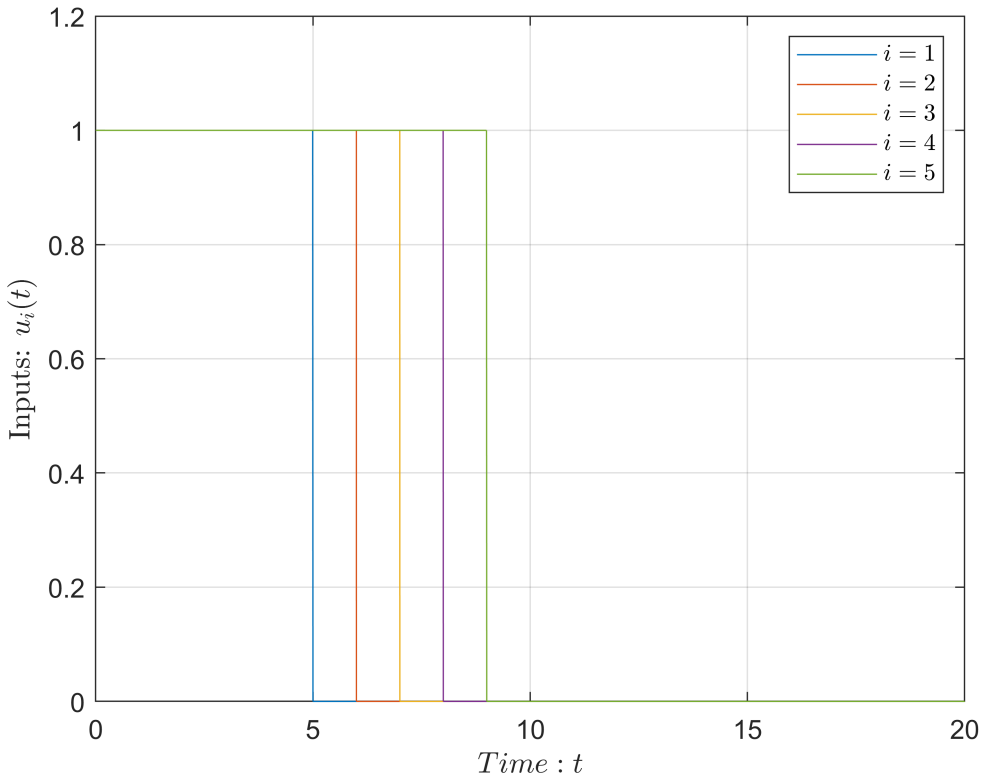
```
for i = 1:1:length(network.subsystems)
    tempStr = keyString+num2str(i)+"} =&\ \left\{";
    for j = 1:1:(i-1)
        K_ij = KMat(height*(i-1)+1:height*i,width*(j-1)+1:width*j);
        K_ji = KMat(height*(j-1)+1:height*j,width*(i-1)+1:width*i);
        if any(K_ij~=0)
            tempStr = tempStr + keyString+num2str(i)+num2str(j)+"}=\bm{"+num2str(K_ij(1,1),form
        end
        if any(K_ji~=0)
            tempStr = tempStr + keyString+num2str(j)+num2str(i)+"}=\bm{"+num2str(K_ji(1,1),form
        end
    end
    K_ii = KMat(height*(i-1)+1:height*i,width*(i-1)+1:width*i);
    tempStr = tempStr + keyString+num2str(i)+num2str(i)+"}=\bm{"+num2str(K_ii(1,1),format)+" &
    disp(tempStr)
end
```

```
A_{c,1} =&\ \left\{A_{c,11}=\bm{-2.007 & 3.739 \\ -8.697 & 3.866}\right\},\\
A_{c,2} =&\ \left\{A_{c,21}=\bm{0.142 & -0.198 \\ 0.019 & 0.194}, A_{c,12}=\bm{-0.079 & -0.319 \\ 0.042 & -0.867}, A
A_{c,3} =&\ \left\{A_{c,31}=\bm{0.057 & 0.119 \\ -0.059 & 0.042}, A_{c,32}=\bm{-0.001 & -0.003 \\ -0.056 & -0.131},
A_{c,4} =&\ \left\{A_{c,41}=\bm{-2.797 & -0.225 \\ 0.427 & 0.087}, A_{c,14}=\bm{0.175 & -1.933 \\ 0.010 & -2.921}, A
A_{c,5} =&\ \left\{A_{c,51}=\bm{-0.147 & 0.044 \\ 0.003 & -0.027}, A_{c,52}=\bm{-0.082 & -0.242 \\ -0.012 & 0.021},
```

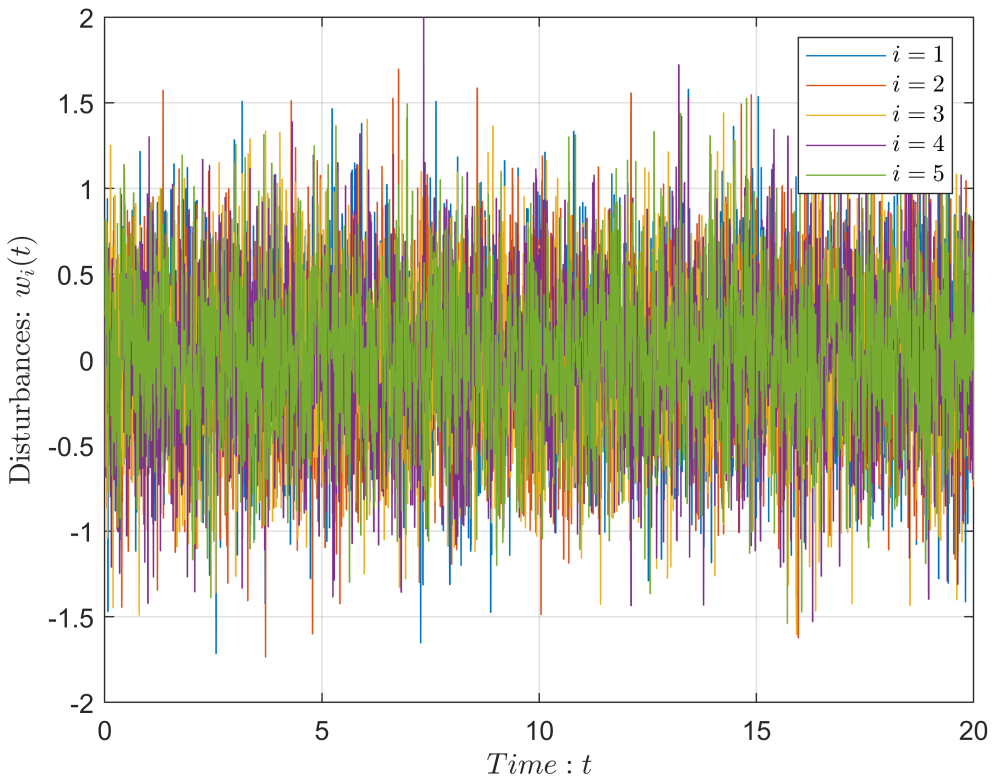
Plots

```
clear all
close all
clc


% This file is connected with the "JSimResultsModel2.slx" file
% Run this after running JSimResults.mlx ------> JSimResultsModel2.slx


load jPaperDataSimulation.mat
t_1 = 0;
t_2 = 20; %25
F_s = 1000; % Sampling freq

% figure(1)
% network.drawNetwork(1,false);
% grid on

figure(1)
u = out.DataInputu(:,2:6);
t = out.DataInputu(:,1);
plot(t,u)
```

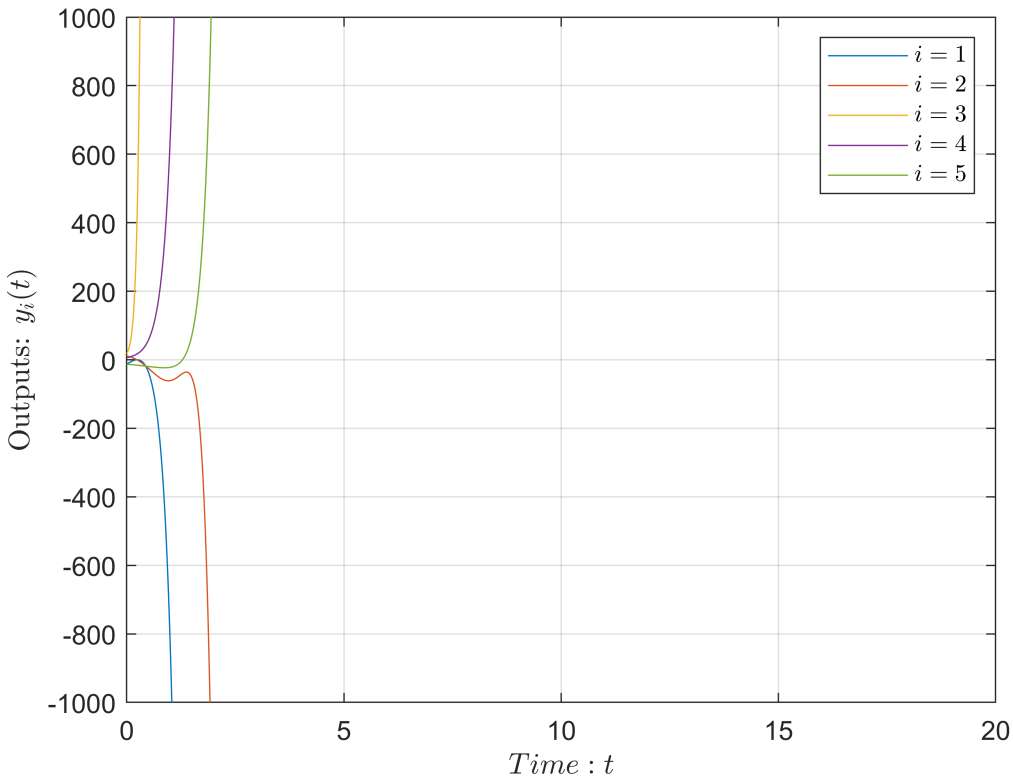
```
ylabel('Inputs: $u_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,0,1.2])
```



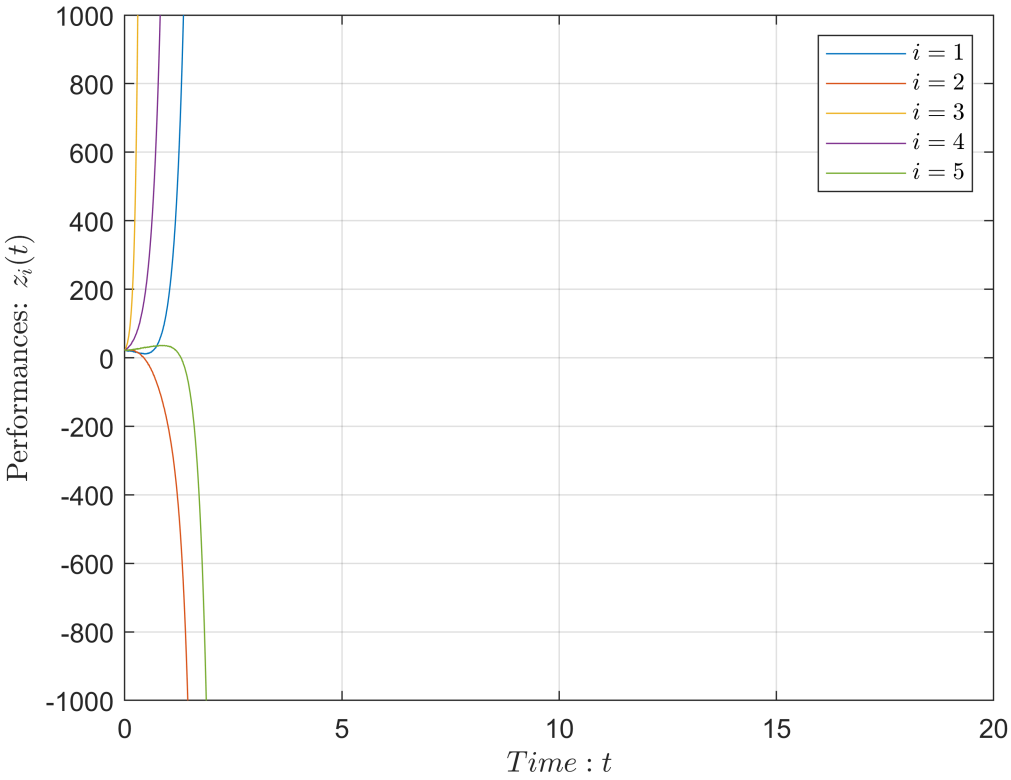

```
figure(2)
w = out.DataDisturbancew(:,2:6);
t = out.DataDisturbancew(:,1);
plot(t,w)
ylabel('Disturbances: $w_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-2,2])
```




```
figure(3)
y = out.DataOpenLoop(:,2:6);
t = out.DataOpenLoop(:,1);
plot(t,y)
ylabel('Outputs: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-1000,1000])
```

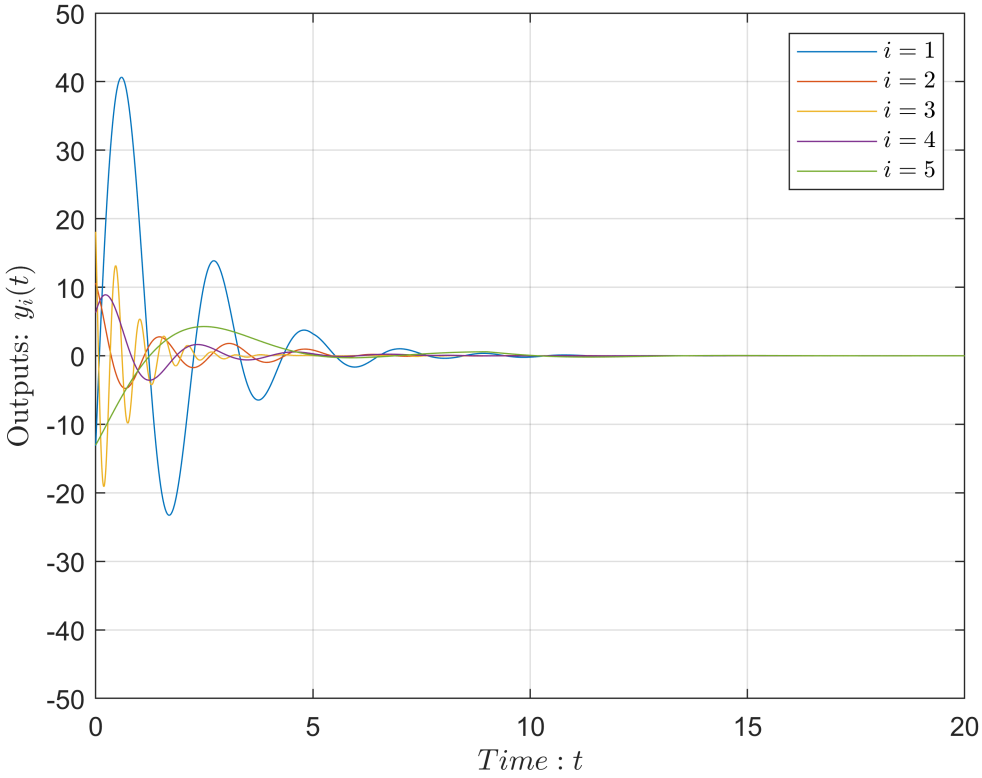



```
figure(4)
z = out.DataPerformancez(:,2:6);
t = out.DataPerformancez(:,1);
plot(t,z)
ylabel('Performances: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-1000,1000])
```



Stabilization Aspects: Centralized vs Decentralized

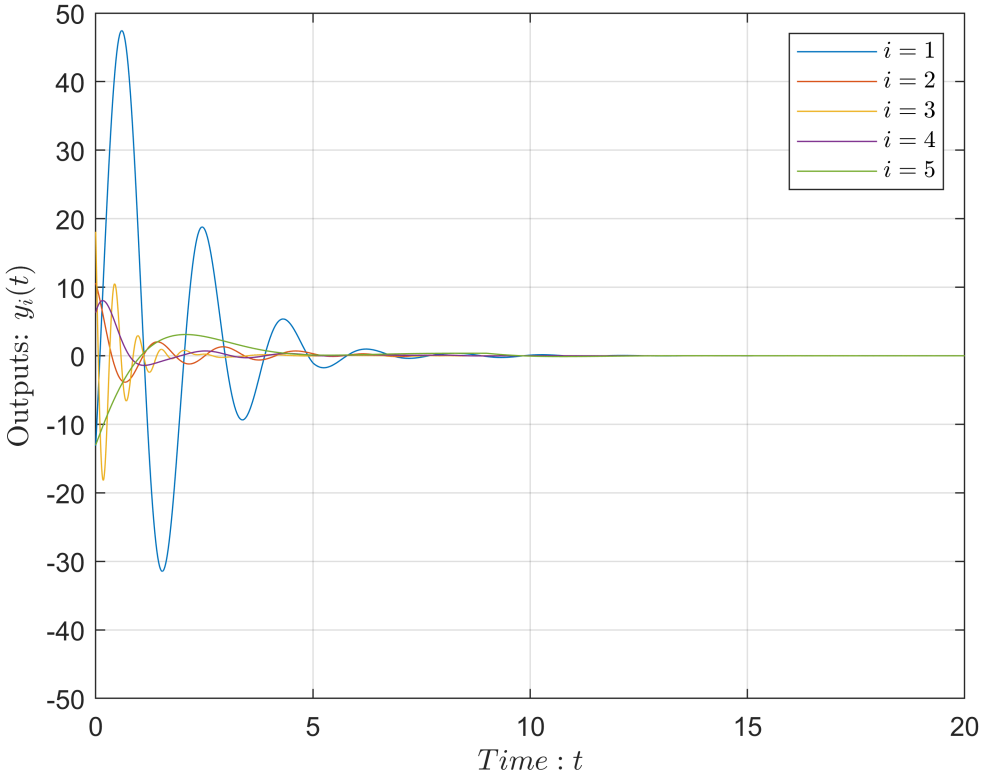
```
% Stabilization FSF
figure(5)
y = out.DataCentStabFSF(:,2:6);
t = out.DataCentStabFSF(:,1);
plot(t,y)
ylabel('Outputs: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-50,50])
```




```
MAO1 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO1 = 1.1209
```

```
figure(6)
y = out.DataDecentStabFSF(:,2:6);
t = out.DataDecentStabFSF(:,1);
plot(t,y)
ylabel('Outputs: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-50,50])
```



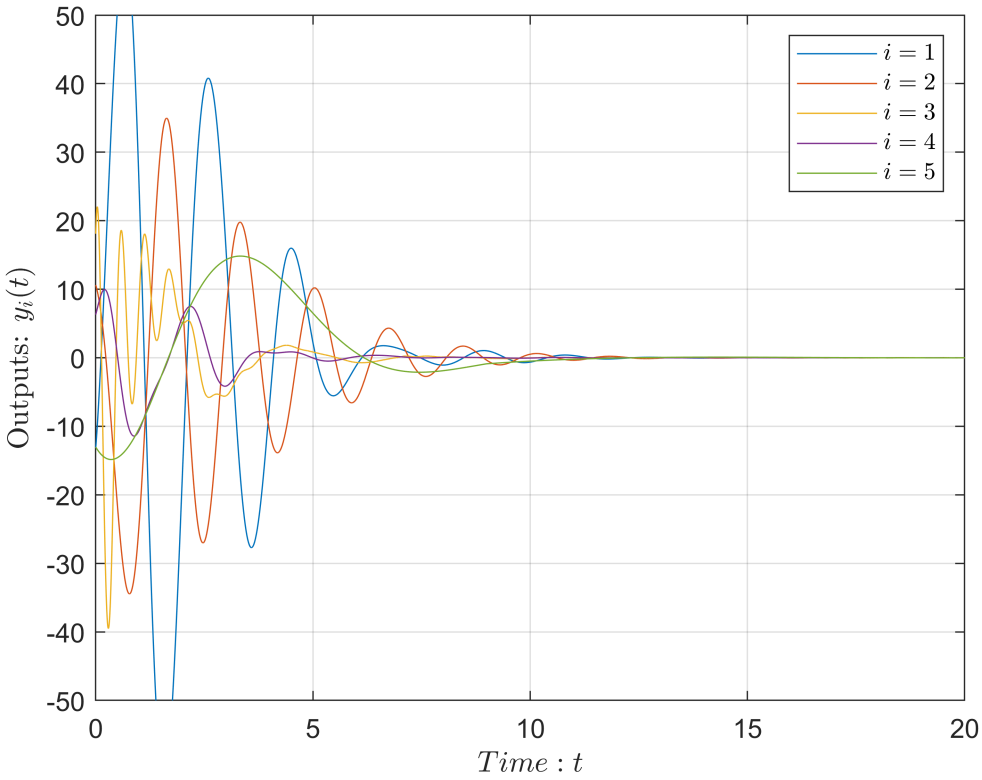

```
MAO2 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO2 = 1.0627
```

```
MAOImprovementPercentage = -(MAO2-MAO1)*100/MAO1
```

```
MAOImprovementPercentage = 5.1868
```

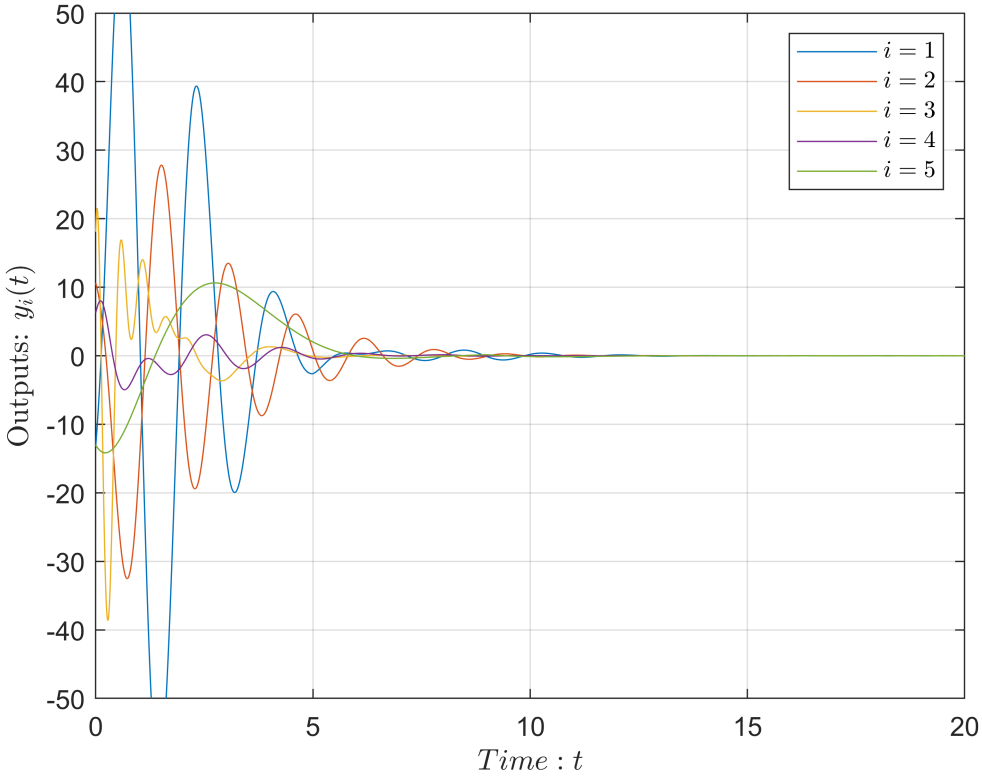
```
% Stabilization FSF+Obs
figure(7)
y = out.DataCentStabObs(:,2:6);
t = out.DataCentStabObs(:,1);
plot(t,y)
ylabel('Outputs: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-50,50])
```




```
MAO1 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO1 = 3.4128
```

```
figure(8)
y = out.DataDecentStabObs(:,2:6);
t = out.DataDecentStabObs(:,1);
plot(t,y)
ylabel('Outputs: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-50,50])
```



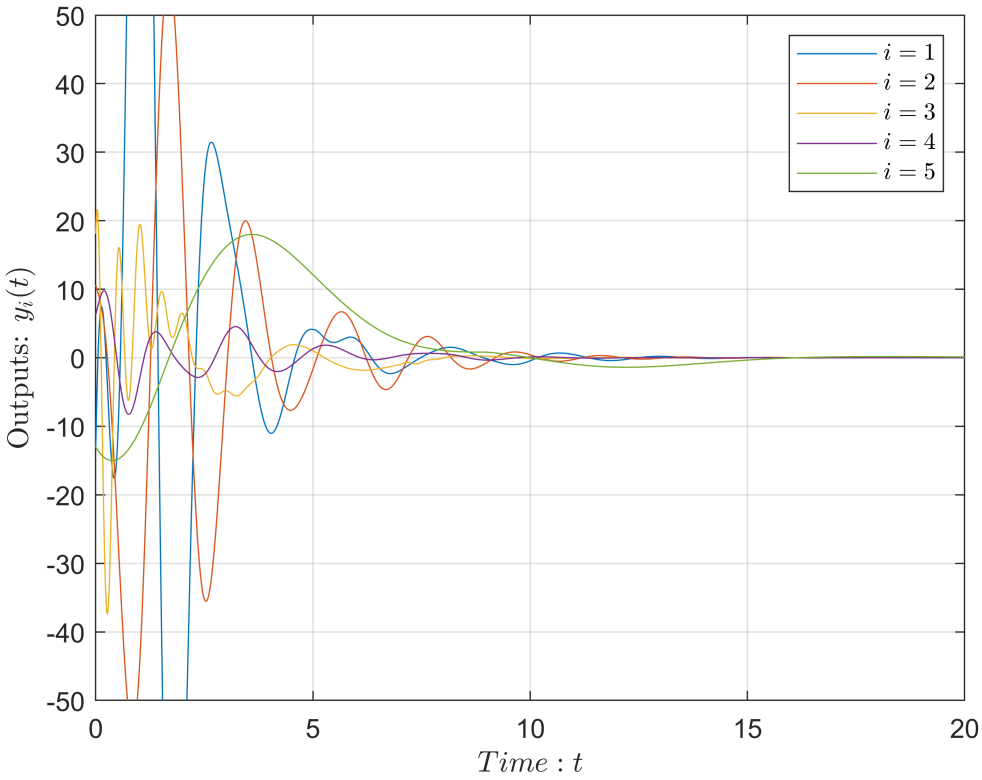

```
MAO2 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO2 = 2.4977
```

```
MAOImprovementPercentage = -(MAO2-MAO1)*100/MAO1
```

```
MAOImprovementPercentage = 26.8117
```

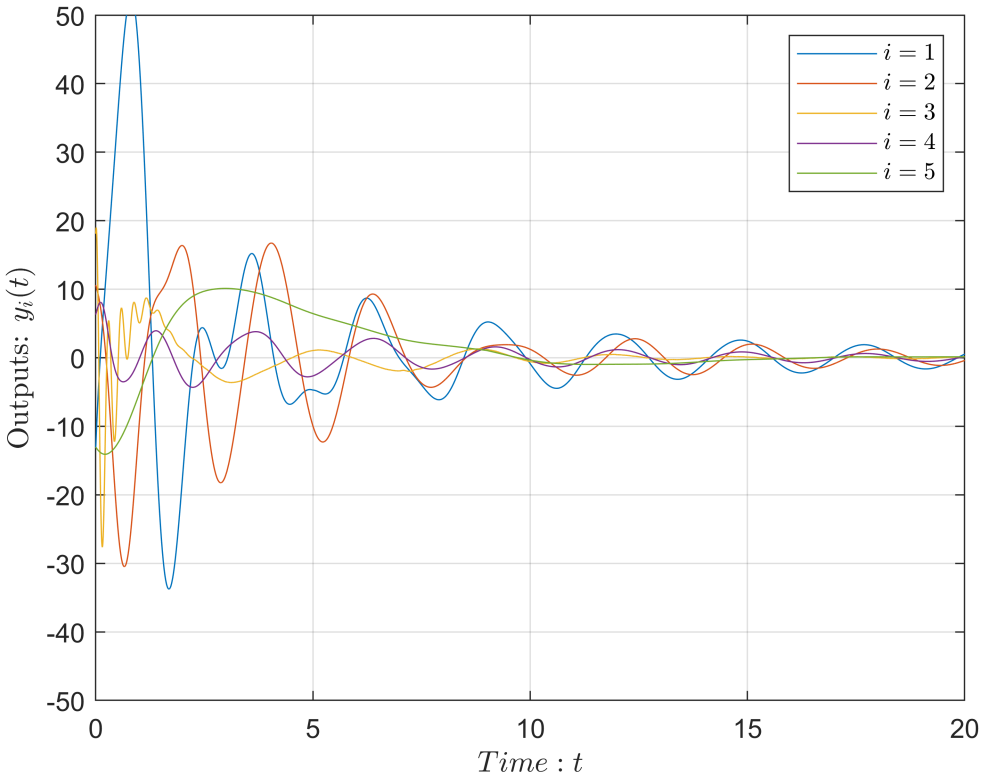
```
% Stabilization DOF
figure(9)
y = out.DataCentStabDOF(:,2:6);
t = out.DataCentStabDOF(:,1);
plot(t,y)
ylabel('Outputs: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-50,50])
```




```
MAO1 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO1 = 4.2274
```

```
figure(10)
y = out.DataDecentStabDOF(:,2:6);
t = out.DataDecentStabDOF(:,1);
plot(t,y)
ylabel('Outputs: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-50,50])
```




```
MAO2 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

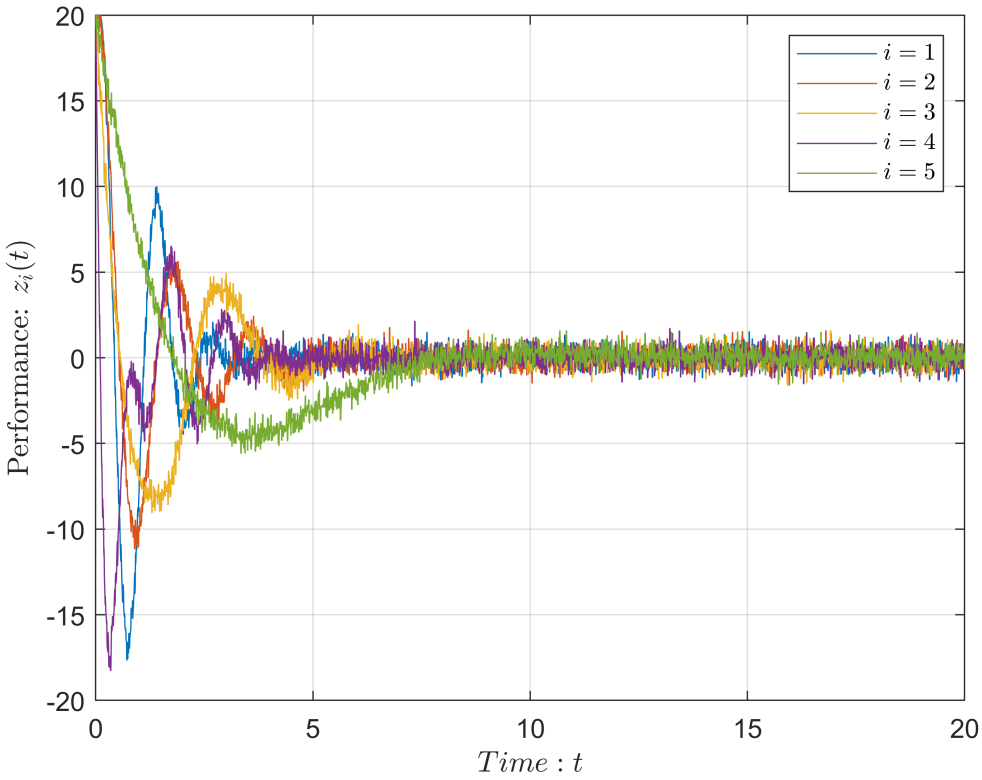
```
MAO2 = 3.1074
```

```
MAOImprovementPercentage = -(MAO2-MAO1)*100/MAO1
```

```
MAOImprovementPercentage = 26.4934
```

Performance: Dissipativity based improvement: Stability vs Dissipativity

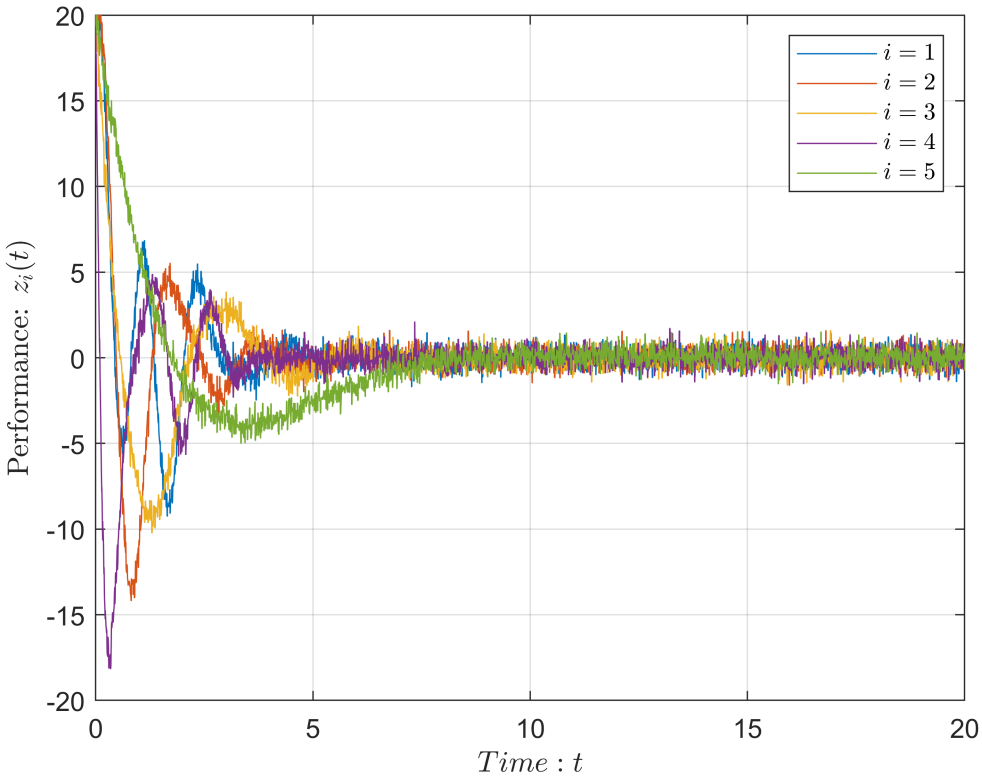
```
% Centralized FSF+Obs
figure(11)
z = out.DataCentStabObsError(:,2:6);
t = out.DataCentStabObsError(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-20,20])
```




```
MAP1 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP1 = 1.3268
```

```
figure(12)
z = out.DataCentDissObsError(:,2:6);
t = out.DataCentDissObsError(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-20,20])
```



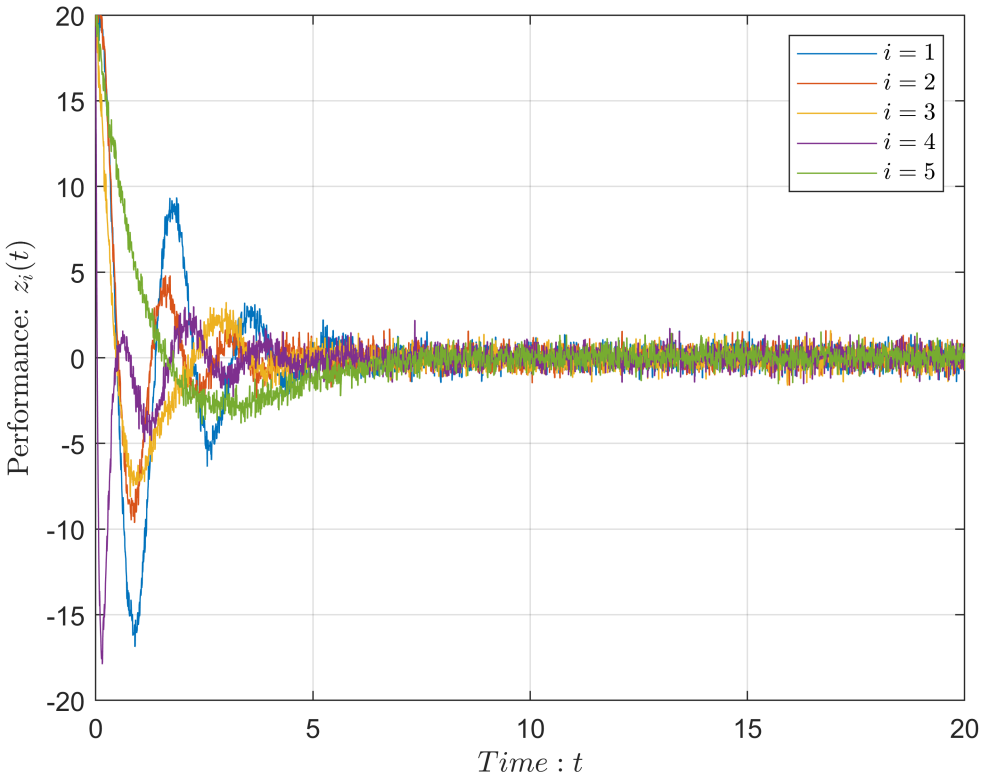

```
MAP2 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP2 = 1.2457
```

```
MAPImprovementPercentage = -(MAP2-MAP1)*100/MAP1
```

```
MAPImprovementPercentage = 6.1124
```

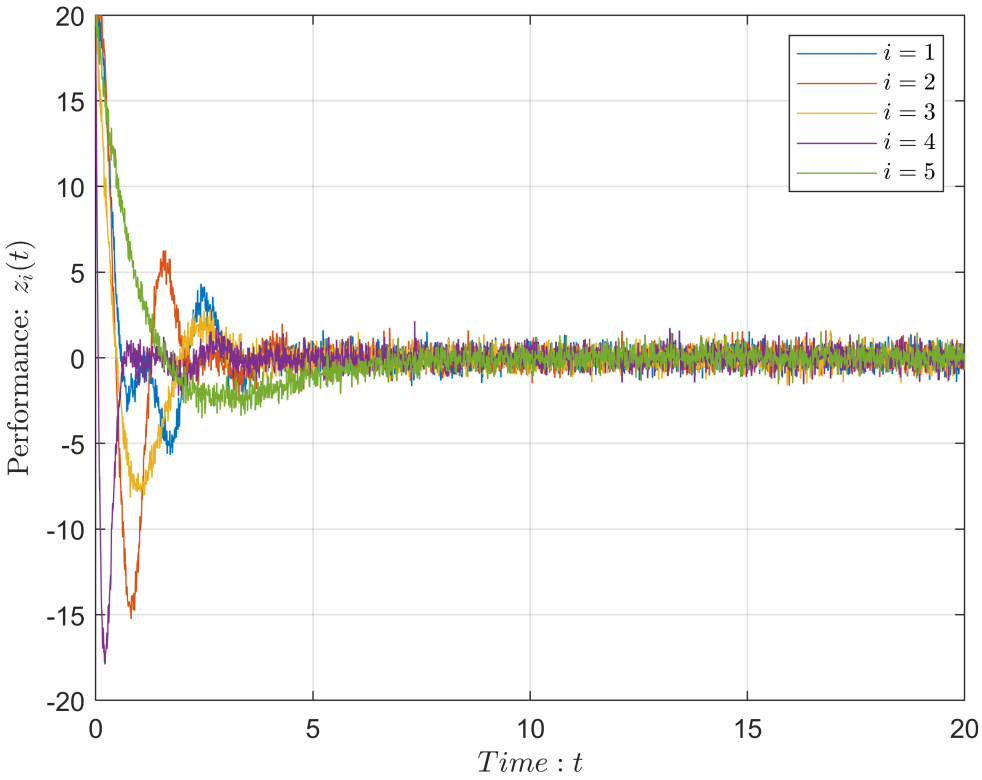
```
% Decentralized FSF+Obs
figure(13)
z = out.DataDecentStabObsError(:,2:6);
t = out.DataDecentStabObsError(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-20,20])
```




```
MAP1 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP1 = 1.1550
```

```
figure(14)
z = out.DataDecentDissObsError(:,2:6);
t = out.DataDecentDissObsError(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-20,20])
```



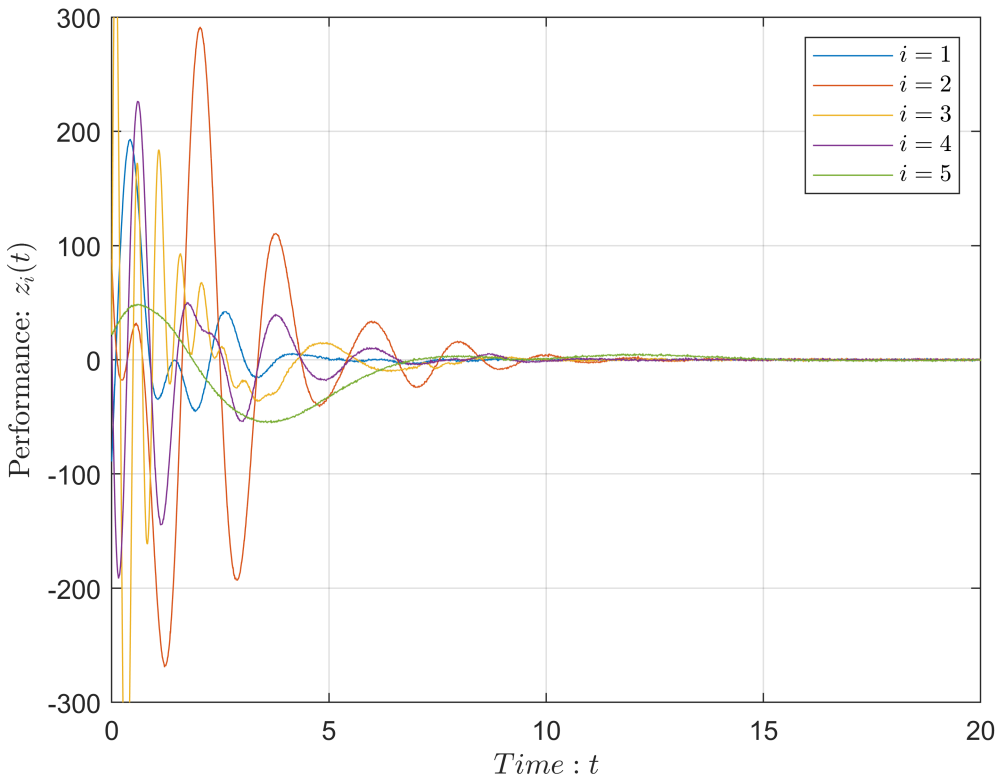

```
MAP2 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP2 = 1.0153
```

```
MAPImprovementPercentage = -(MAP2-MAP1)*100/MAP1
```

```
MAPImprovementPercentage = 12.1010
```

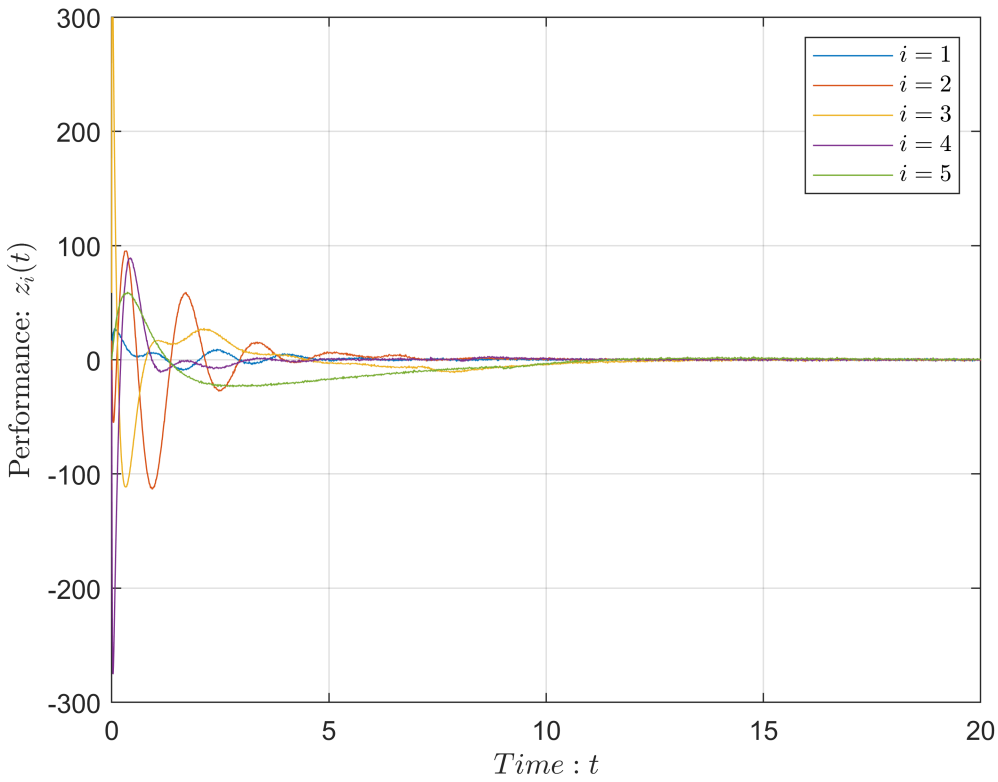
```
% Centralized DOF
figure(15)
z = out.DataCentStabDOFPerf(:,2:6);
t = out.DataCentStabDOFPerf(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-300,300])
```




```
MAP1 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP1 = 16.0107
```

```
figure(16)
z = out.DataCentDissDOFPerf(:,2:6);
t = out.DataCentDissDOFPerf(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-300,300])
```



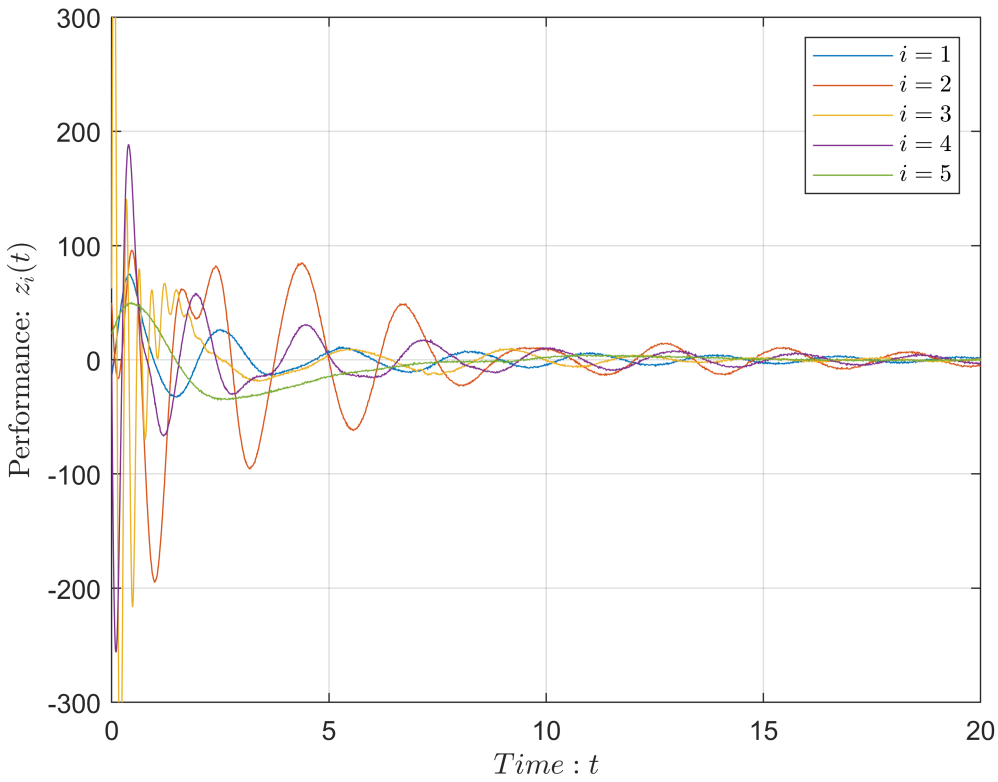

```
MAP2 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP2 = 5.9660
```

```
MAPImprovementPercentage = -(MAP2-MAP1)*100/MAP1
```

```
MAPImprovementPercentage = 62.7372
```

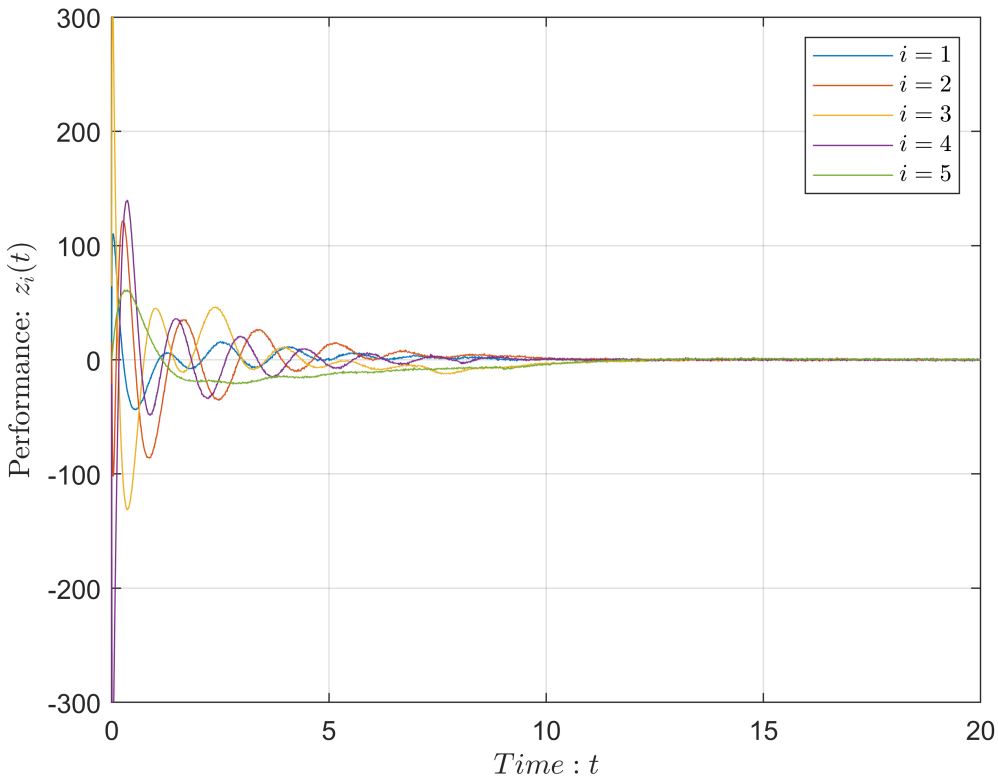
```
% Decentralized DOF
figure(17)
z = out.DataDecentStabDOFPerf(:,2:6);
t = out.DataDecentStabDOFPerf(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-300,300])
```




```
MAP1 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP1 = 13.3650
```

```
figure(18)
z = out.DataDecentDissDOFPerf(:,2:6);
t = out.DataDecentDissDOFPerf(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-300,300])
```




```
MAP2 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

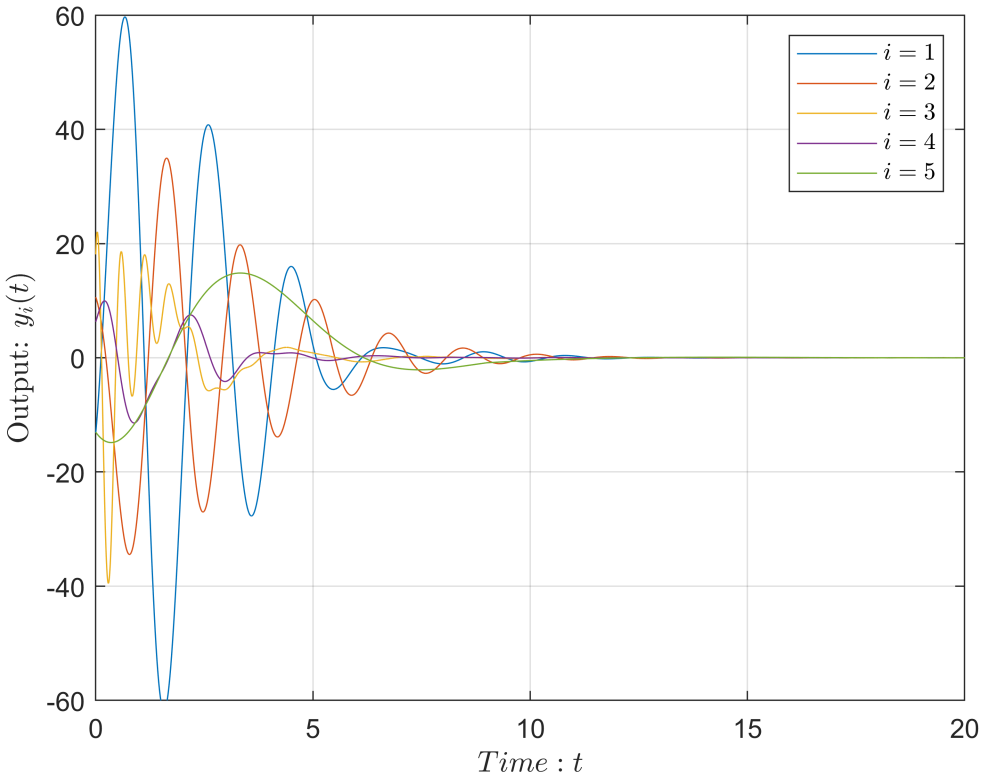
```
MAP2 = 7.3233
```

```
MAPImprovementPercentage = -(MAP2-MAP1)*100/MAP1
```

```
MAPImprovementPercentage = 45.2053
```

(Testing, omit these) Output: Dissipativity based improvement: Stability vs Dissipativity

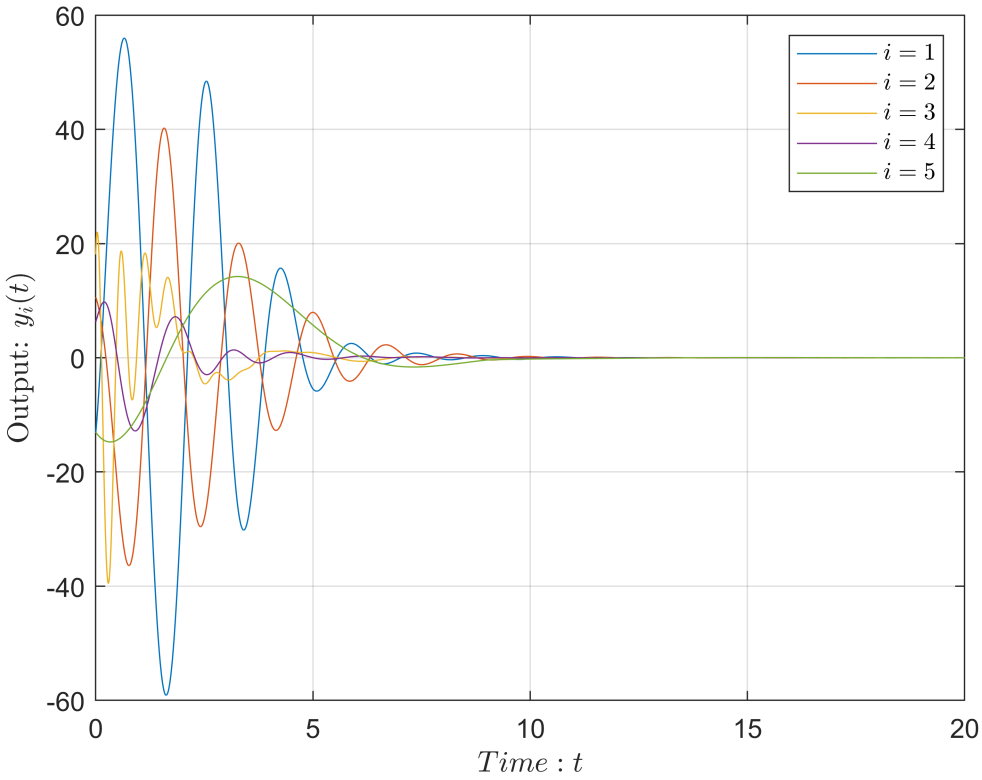
```
% Centralized FSF+Obs
figure(19)
y = out.DataCentStabObs(:,2:6);
t = out.DataCentStabObs(:,1);
plot(t,y)
ylabel('Output: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```




```
MAO1 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO1 = 3.4128
```

```
figure(20)
y = out.DataCentDissObs(:,2:6);
t = out.DataCentDissObs(:,1);
plot(t,y)
ylabel('Output: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```



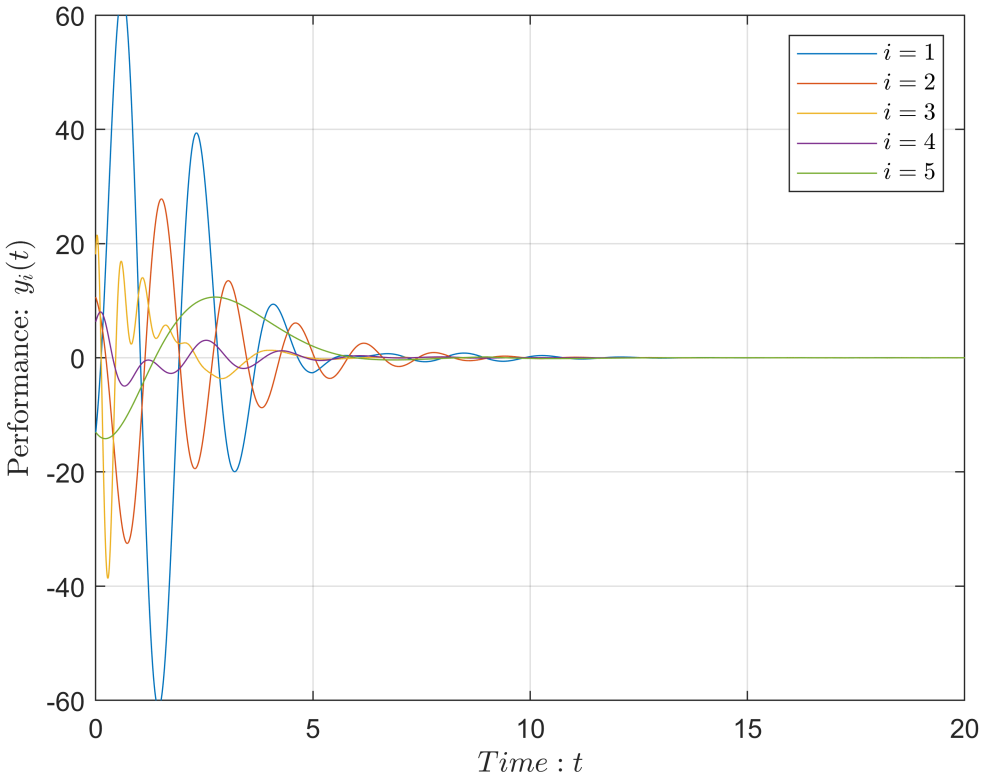

```
MAO2 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO2 = 3.2615
```

```
MAOImprovementPercentage = -(MAO2-MAO1)*100/MAO1
```

```
MAOImprovementPercentage = 4.4308
```

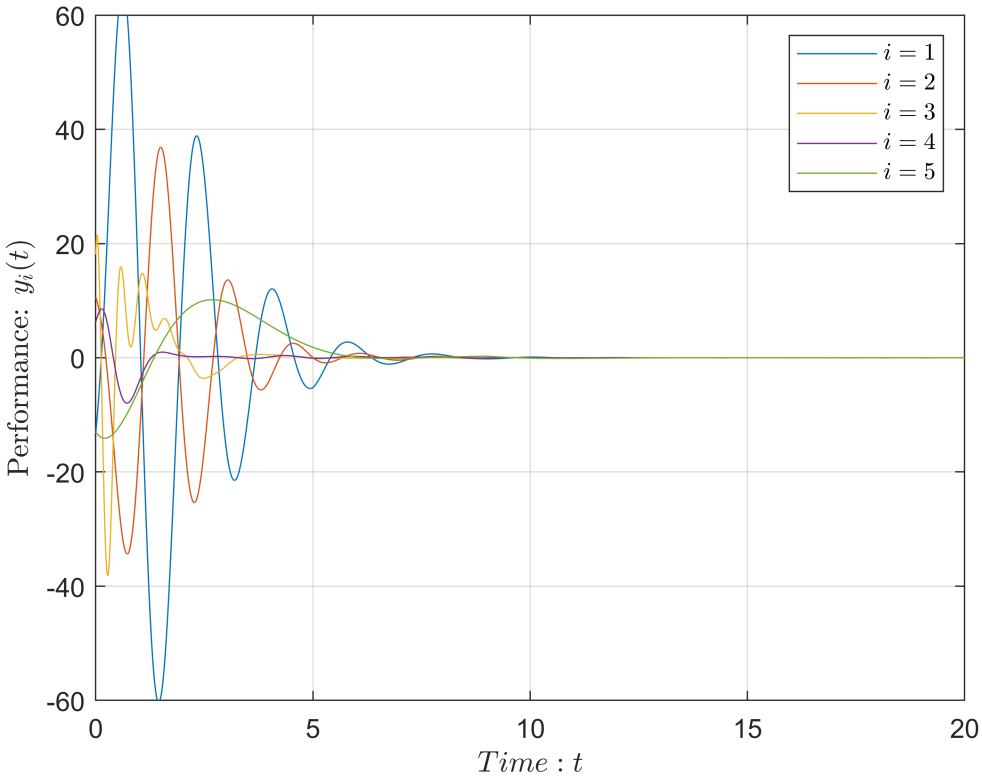
```
% Decentralized FSF+Obs
figure(21)
y = out.DataDecentStabObs(:,2:6);
t = out.DataDecentStabObs(:,1);
plot(t,y)
ylabel('Performance: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```




```
MAO1 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO1 = 2.4977
```

```
figure(22)
y = out.DataDecentDissObs(:,2:6);
t = out.DataDecentDissObs(:,1);
plot(t,y)
ylabel('Performance: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```



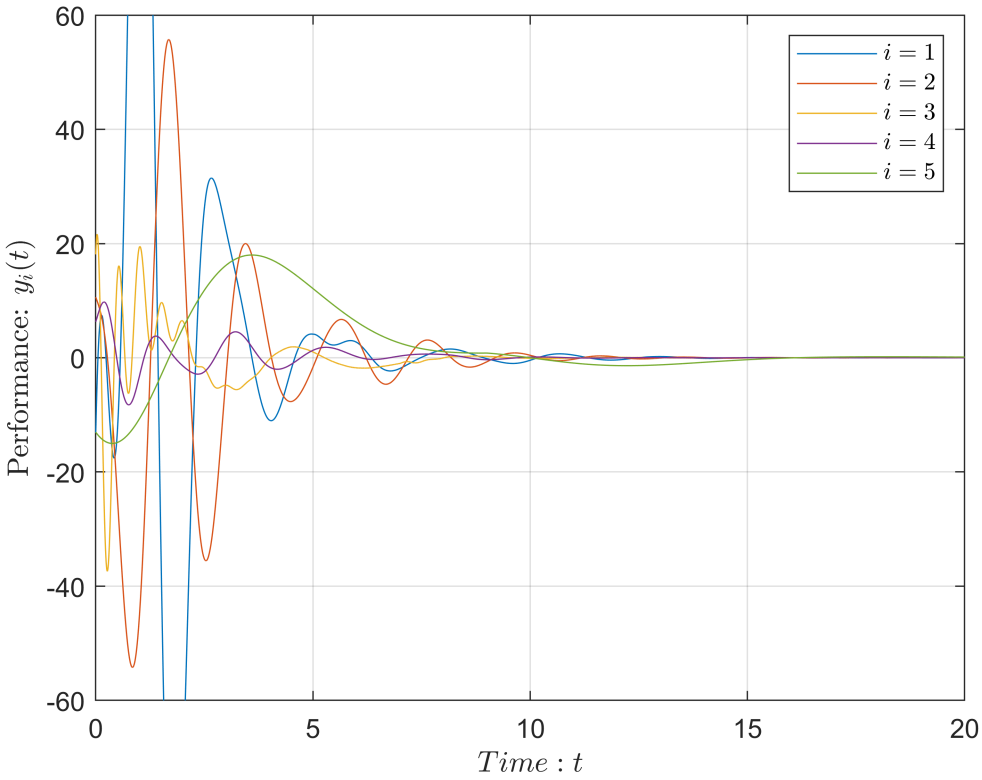

```
MAO2 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO2 = 2.4926
```

```
MAOImprovementPercentage = -(MAO2-MAO1)*100/MAO1
```

```
MAOImprovementPercentage = 0.2043
```

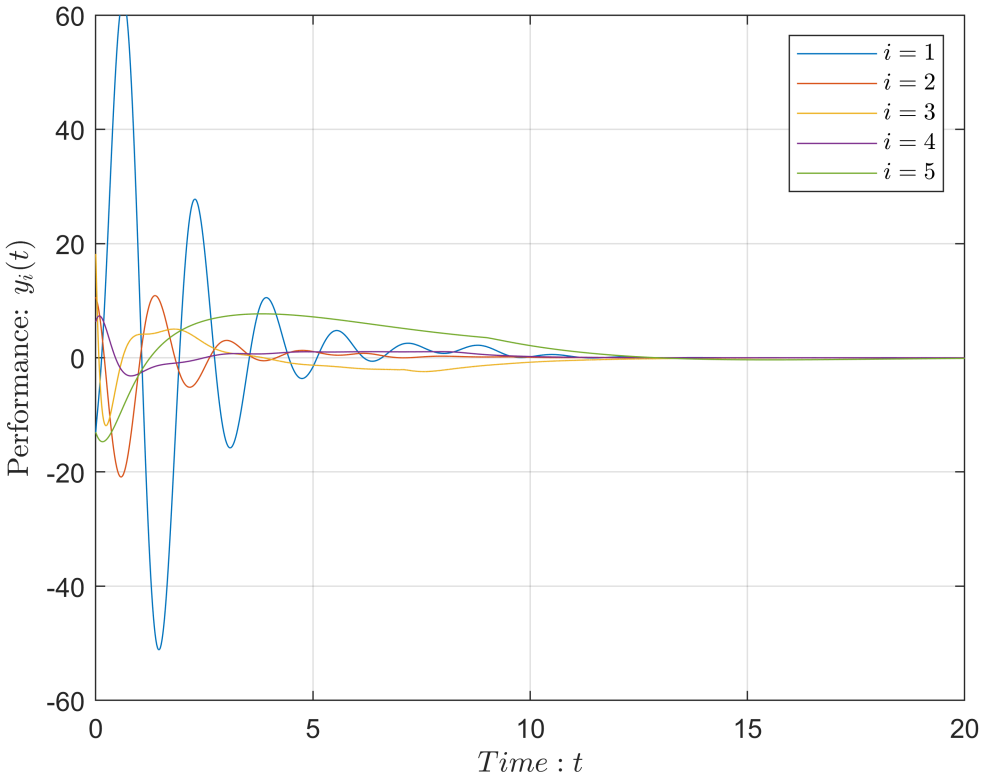
```
% Centralized DOF
figure(23)
y = out.DataCentStabDOF(:,2:6);
t = out.DataCentStabDOF(:,1);
plot(t,y)
ylabel('Performance: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```




```
MAO1 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO1 = 4.2274
```

```
figure(24)
y = out.DataCentDissDOF(:,2:6);
t = out.DataCentDissDOF(:,1);
plot(t,y)
ylabel('Performance: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```



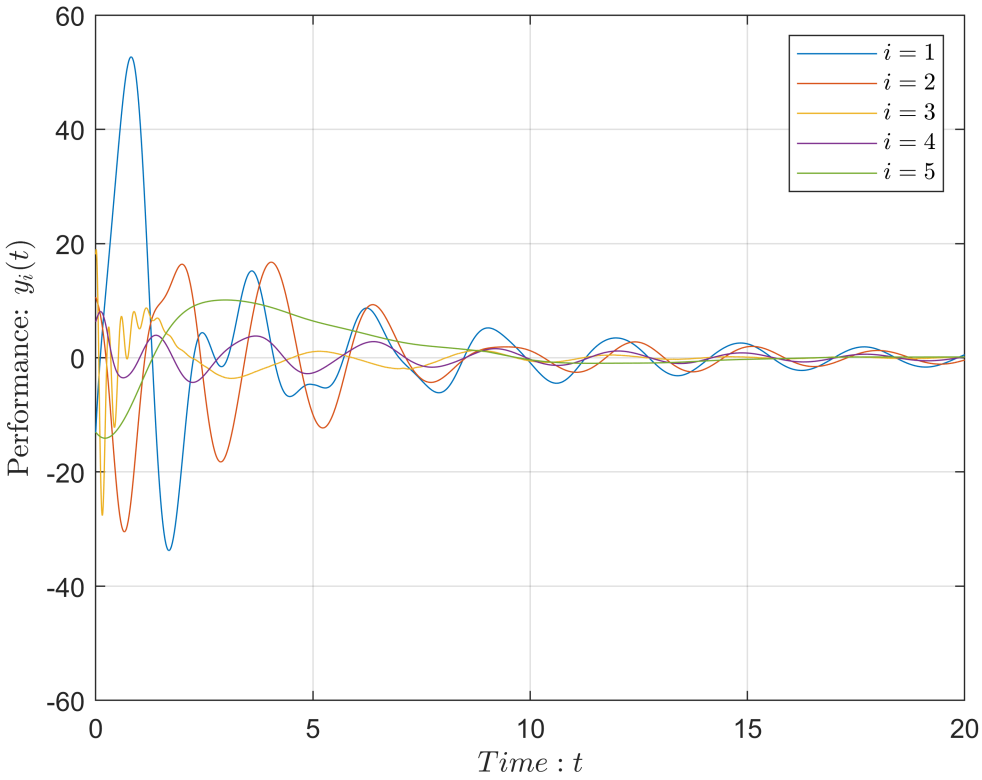

```
MAO2 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO2 = 2.2420
```

```
MAOImprovementPercentage = -(MAO2-MAO1)*100/MAO1
```

```
MAOImprovementPercentage = 46.9646
```

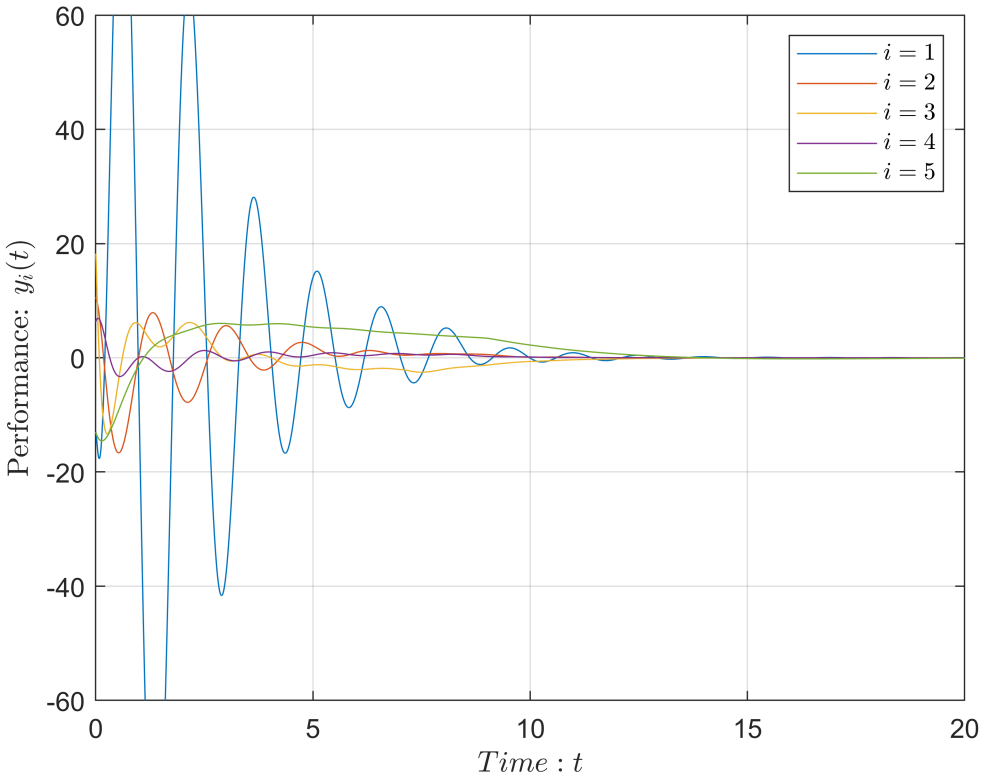
```
% Decentralized DOF
figure(25)
y = out.DataDecentStabDOF(:,2:6);
t = out.DataDecentStabDOF(:,1);
plot(t,y)
ylabel('Performance: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```




```
MAO1 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO1 = 3.1074
```

```
figure(26)
y = out.DataDecentDissDOF(:,2:6);
t = out.DataDecentDissDOF(:,1);
plot(t,y)
ylabel('Performance: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```




```
MAO2 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

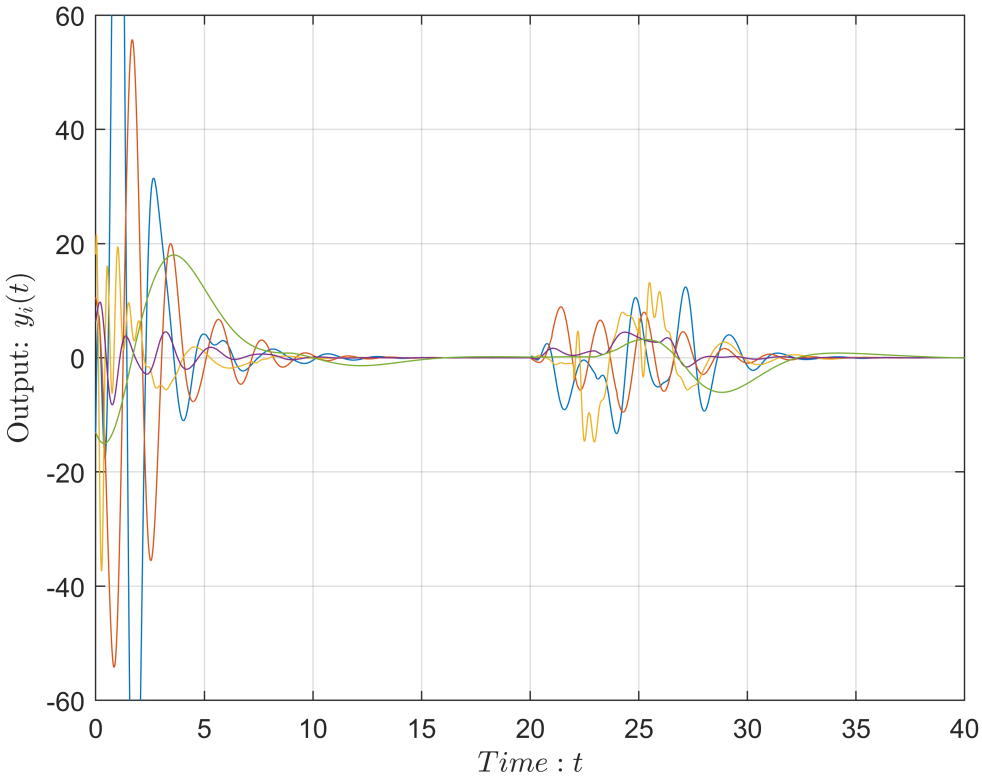
```
MAO2 = 3.0726
```

```
MAOImprovementPercentage = -(MAO2-MAO1)*100/MAO1
```

```
MAOImprovementPercentage = 1.1205
```

Disturbance Rejection: DOF for y(t) and z(t)

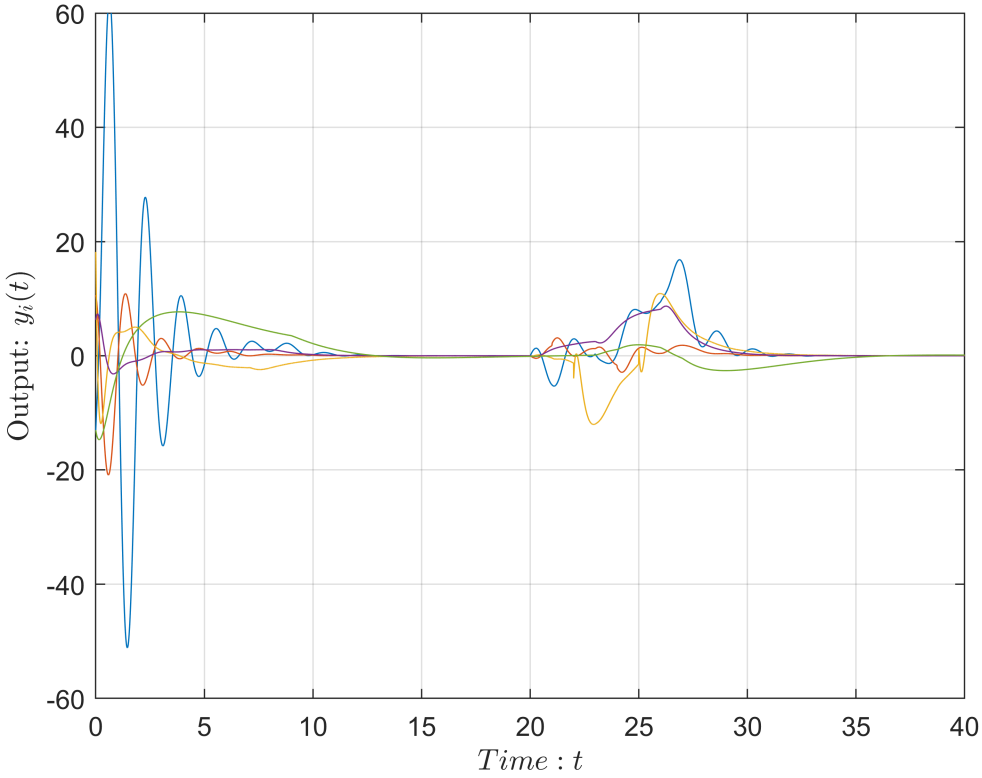
```
load jPaperDataSimulationWithDist.mat
t_1 = 0;
t_2 = 40;
F_s = 1000; % Sampling freq

% Output: Centralized DOF
figure(27)
y = out.DataCentStabDOF(:,2:6);
t = out.DataCentStabDOF(:,1);
plot(t,y)
ylabel('Output: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
% legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```




```
MAO1 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO1 = 2.9778
```

```
figure(28)
y = out.DataCentDissDOF(:,2:6);
t = out.DataCentDissDOF(:,1);
plot(t,y)
ylabel('Output: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
% legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```



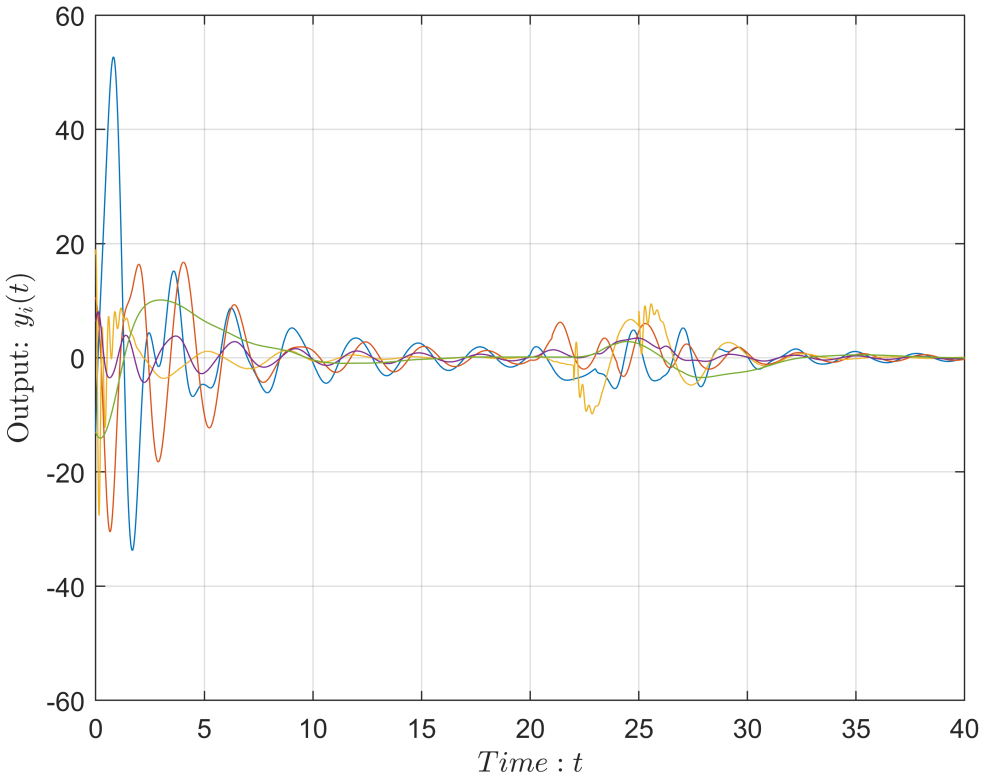

```
MAO2 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO2 = 1.8900
```

```
MAOImprovementPercentage = -(MAO2-MAO1)*100/MAO1
```

```
MAOImprovementPercentage = 36.5286
```

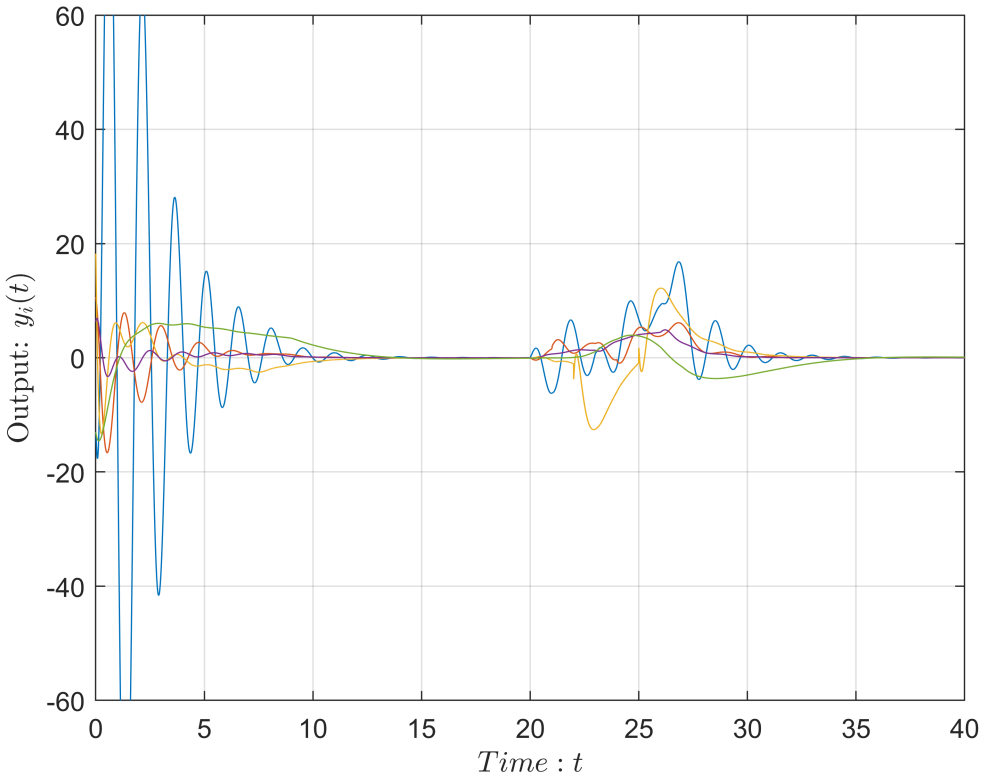
```
% Output: Decentralized DOF
figure(29)
y = out.DataDecentStabDOF(:,2:6);
t = out.DataDecentStabDOF(:,1);
plot(t,y)
ylabel('Output: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
% legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```




```
MAO1 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO1 = 2.2188
```

```
figure(30)
y = out.DataDecentDissDOF(:,2:6);
t = out.DataDecentDissDOF(:,1);
plot(t,y)
ylabel('Output: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
% legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
```



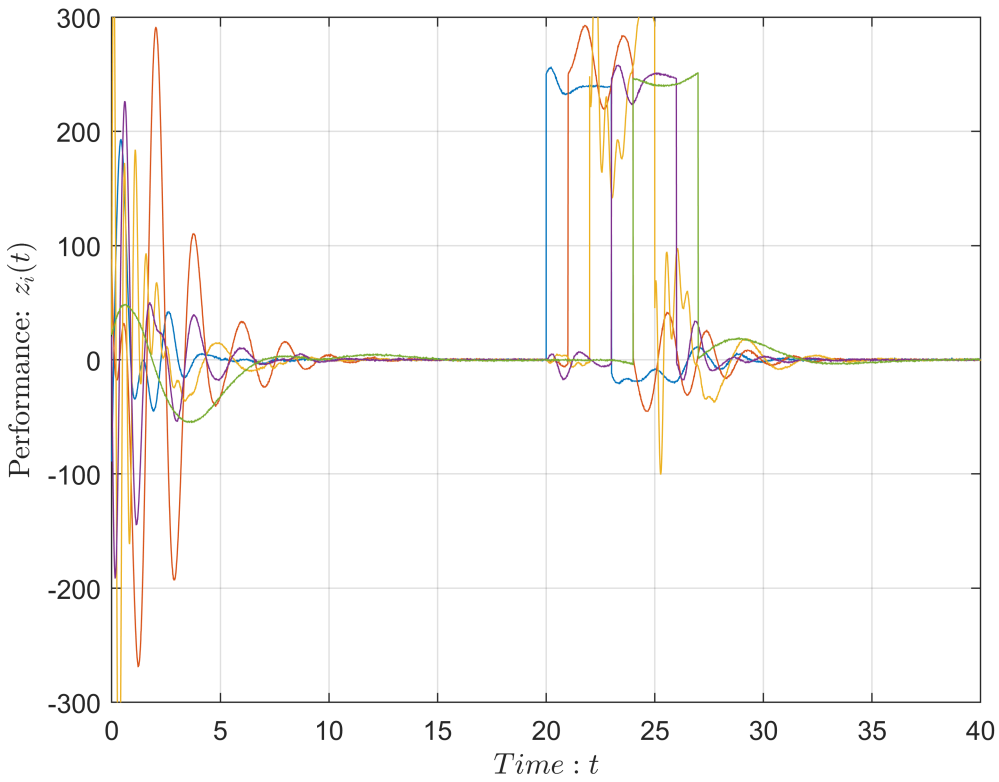

```
MAO2 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO2 = 2.3695
```

```
MAOImprovementPercentage = -(MAO2-MAO1)*100/MAO1
```

```
MAOImprovementPercentage = -6.7905
```

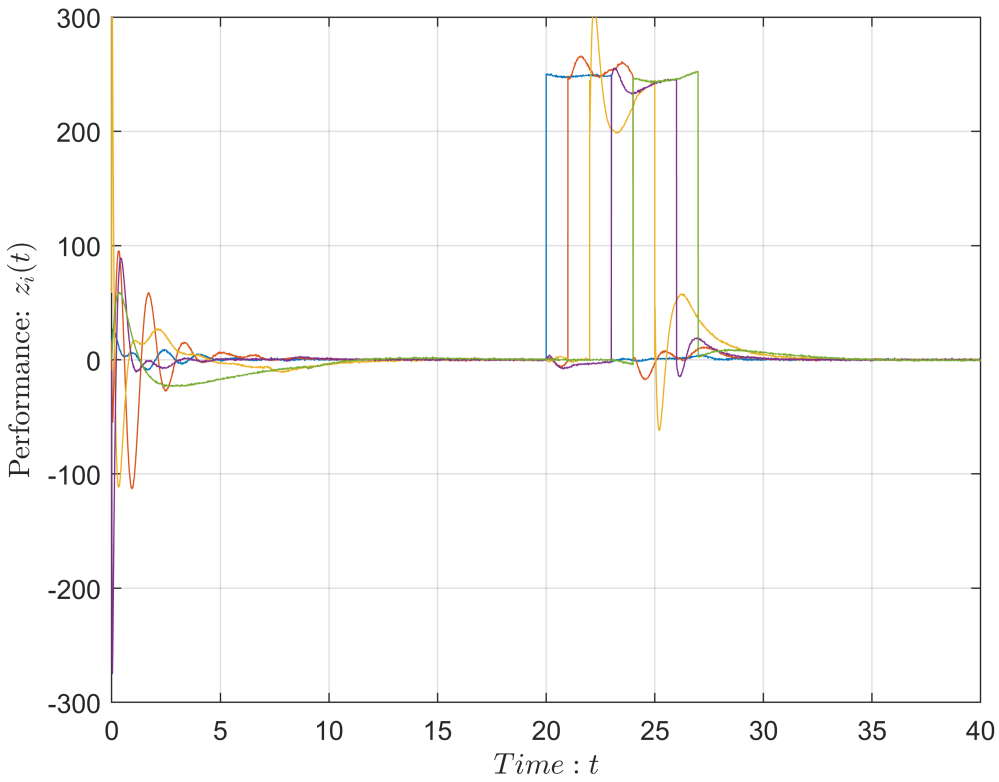
```
% Perf: Centralized DOF
figure(31)
z = out.DataCentStabDOFPerf(:,2:6);
t = out.DataCentStabDOFPerf(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
% legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-300,300])
```




```
MAP1 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP1 = 28.9752
```

```
figure(32)
z = out.DataCentDissDOFPerf(:,2:6);
t = out.DataCentDissDOFPerf(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
% legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-300,300])
```



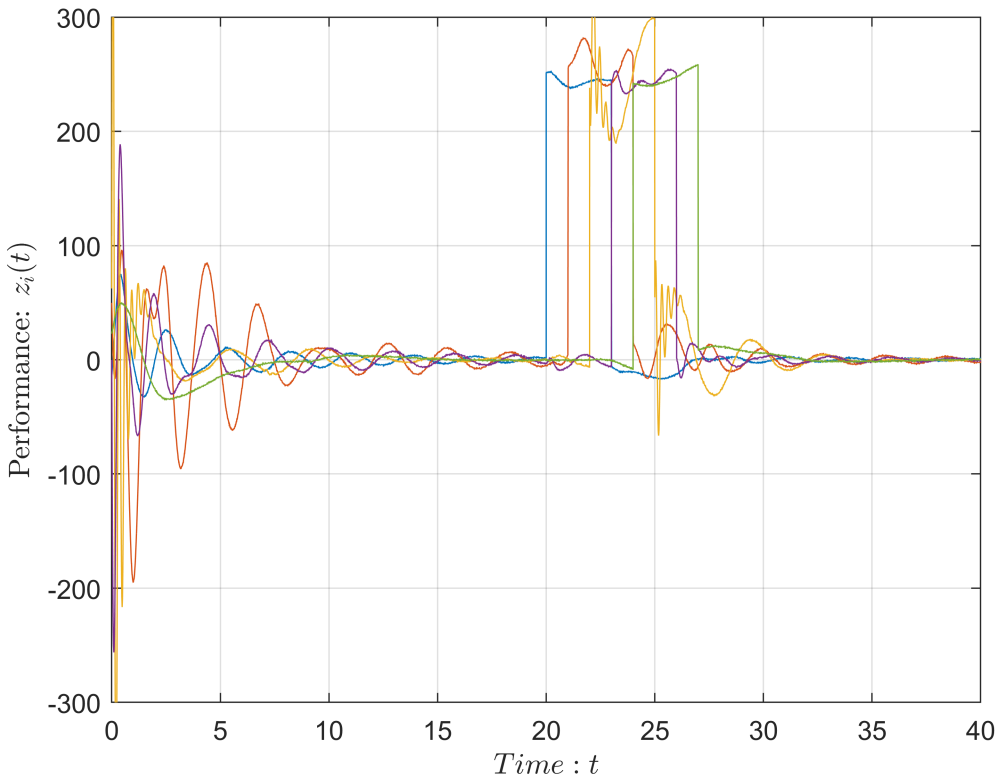

```
MAP2 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP2 = 22.6994
```

```
MAPImprovementPercentage = -(MAP2-MAP1)*100/MAP1
```

```
MAPImprovementPercentage = 21.6591
```

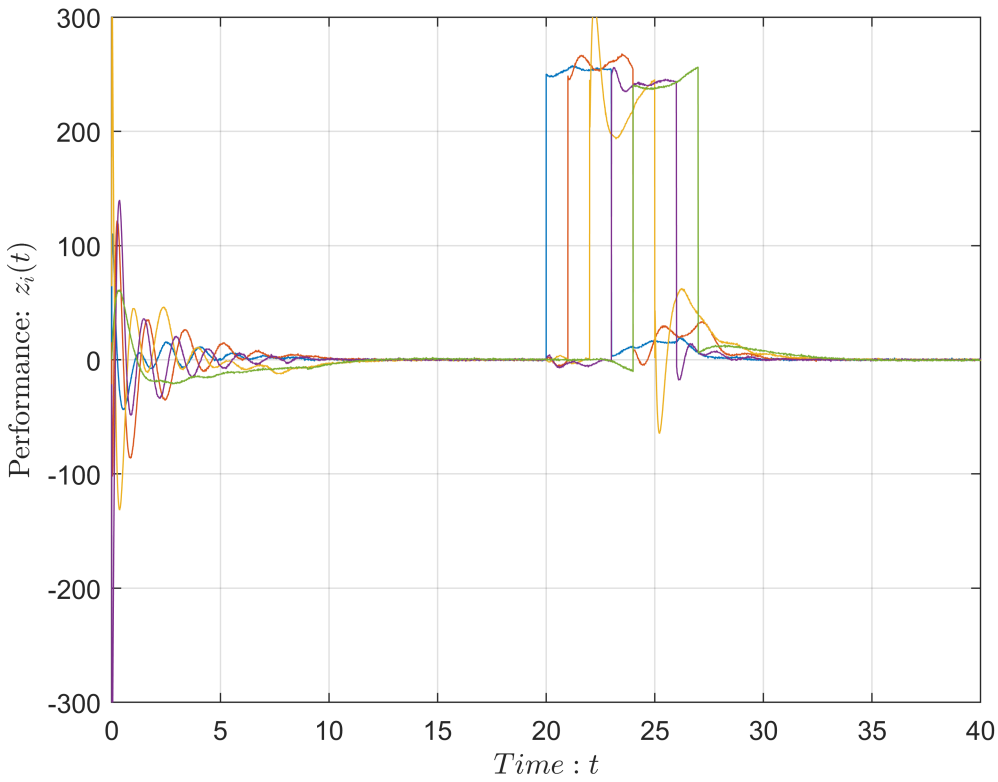
```
% Perf: Decentralized DOF
figure(33)
z = out.DataDecentStabDOFPerf(:,2:6);
t = out.DataDecentStabDOFPerf(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
% legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-300,300])
```




```
MAP1 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP1 = 27.2643
```

```
figure(34)
z = out.DataDecentDissDOFPerf(:,2:6);
t = out.DataDecentDissDOFPerf(:,1);
plot(t,z)
ylabel('Performance: $z_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
% legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-300,300])
```



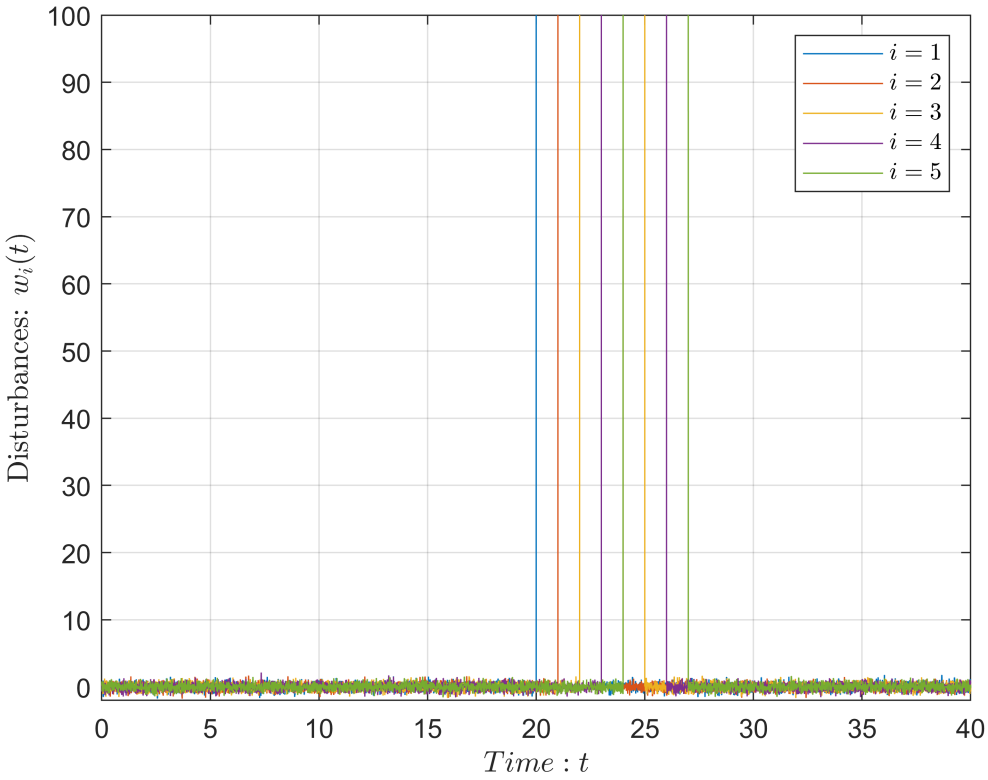

```
MAP2 = mean(mean(abs(z(t_1*F_s+1:t_2*F_s,:))))
```

```
MAP2 = 24.0450
```

```
MAPImprovementPercentage = -(MAP2-MAP1)*100/MAP1
```

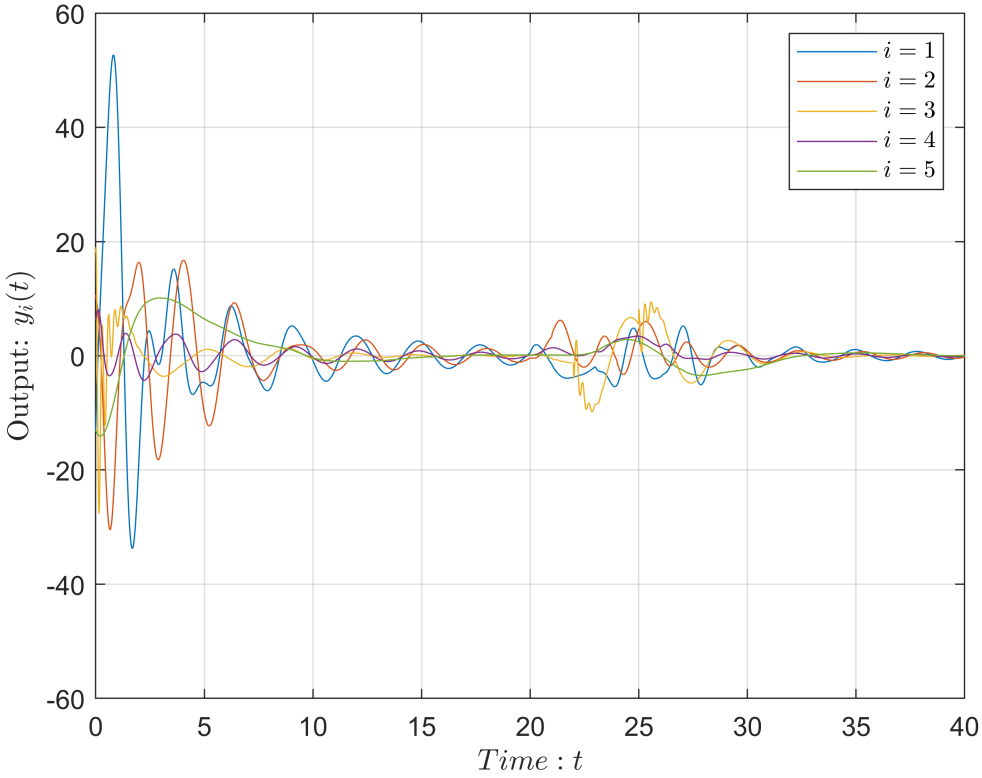
```
MAPImprovementPercentage = 11.8079
```

```
figure(35)
w = out.DataDisturbancew(:,2:6);
t = out.DataDisturbancew(:,1);
plot(t,w)
ylabel('Disturbances: $w_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-2,100])
```



Frequency Domain View: Disturbance Rejection: DOF for y(t) and z(t)

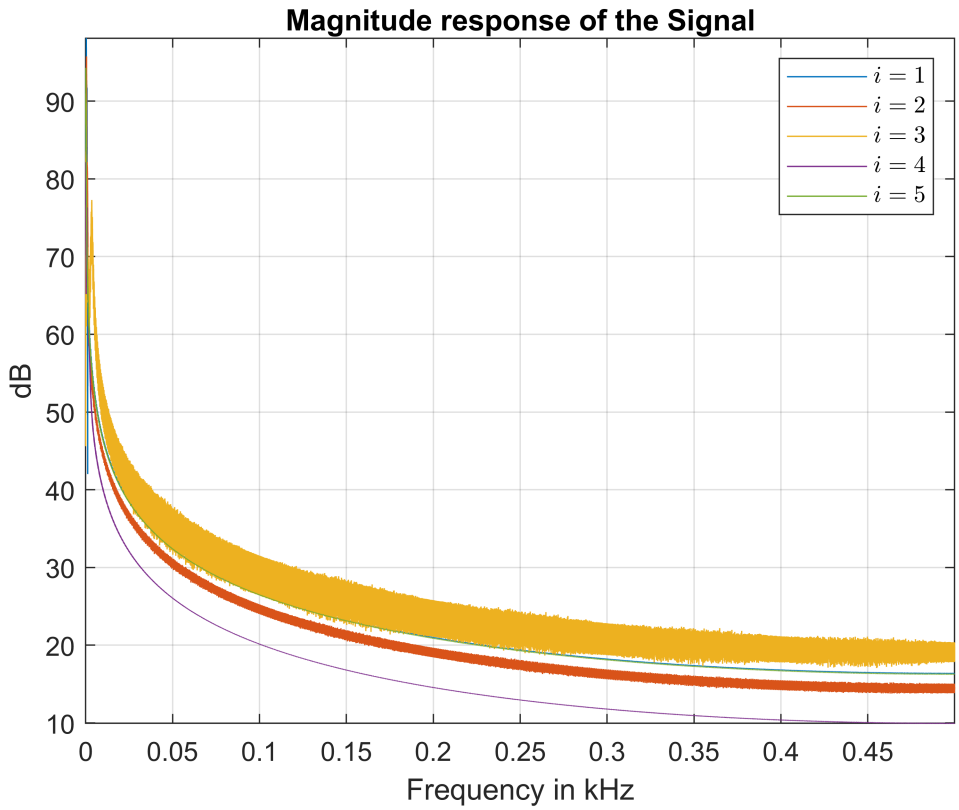
```
load jPaperDataSimulationWithDist.mat
t_1 = 0;
t_2 = 40;
F_s = 1000; % Sampling freq

%% Output profile of Decentralized DOF: Stabilization vs Dissipativation

% Stabilization
figure(29)
y = out.DataDecentStabDOF(:,2:6);
t = out.DataDecentStabDOF(:,1);
plot(t,y)
ylabel('Output: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
% legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
```




```
MAO1 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO1 = 2.2188
```

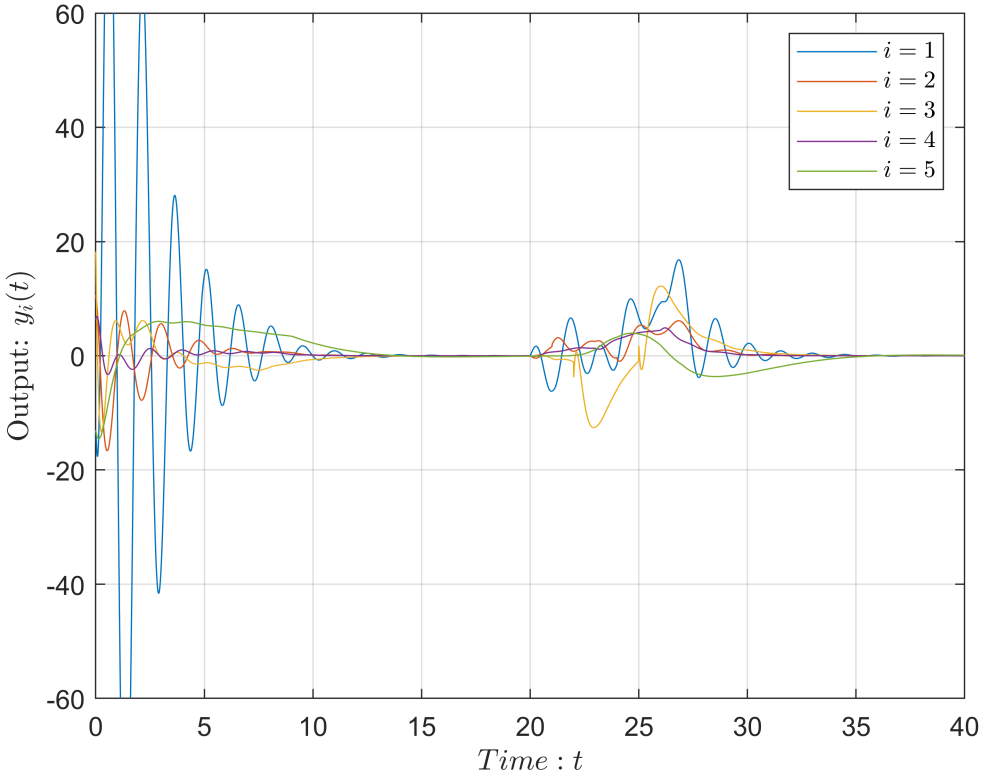
```
% FFT
NFFT = length(y);
Y = fft(y,NFFT);
F = ((0:1/NFFT:1-1/NFFT)*F_s).';
magnitudeY = abs(Y);        % Magnitude of the FFT
phaseY = unwrap(angle(Y));  % Phase of the FFT
frequencyAnalysisPlot(F,magnitudeY,phaseY,NFFT)
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
```




```
MeanMagValues1 = mean(abs(Y))
```

```
MeanMagValues1 = 1×5
   86.8599   60.2468   72.6007   26.4671   49.2342
```

```
% Dissipativation
figure(30)
y = out.DataDecentDissDOF(:,2:6);
t = out.DataDecentDissDOF(:,1);
plot(t,y)
ylabel('Output: $y_i(t)$','interpreter','latex')
xlabel('$Time: t$','interpreter','latex')
% legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
grid on
axis([t_1,t_2,-60,60])
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
```



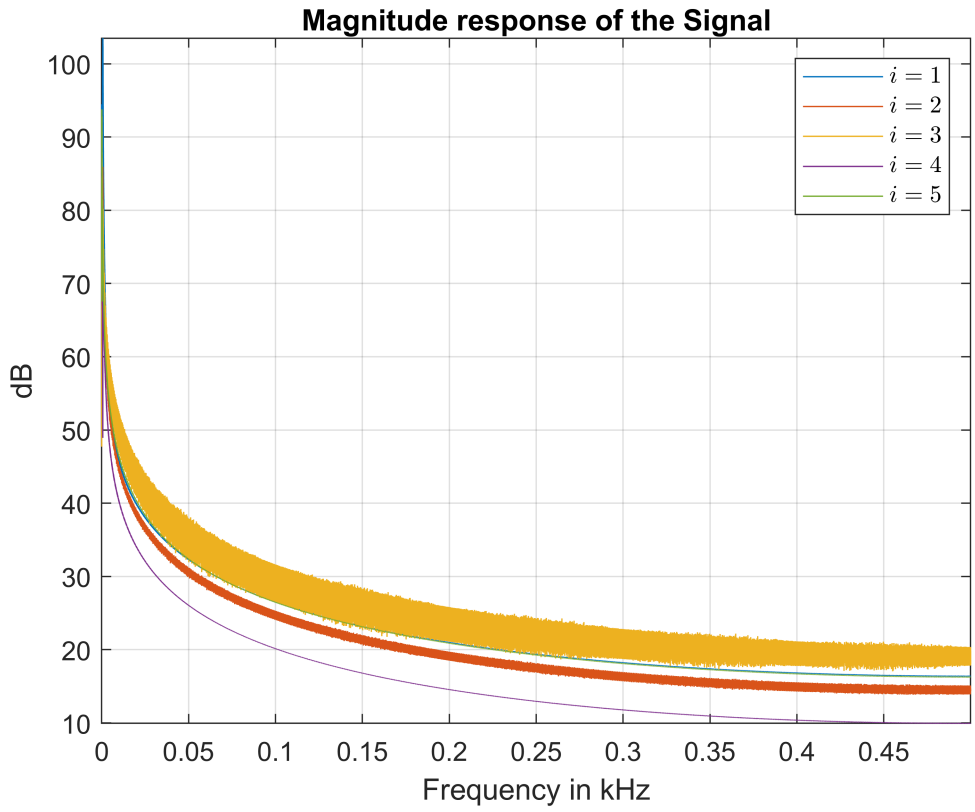

```
MAO2 = mean(mean(abs(y(t_1*F_s+1:t_2*F_s,:))))
```

```
MAO2 = 2.3695
```

```
MAOImprovementPercentage = -(MAO2-MAO1)*100/MAO1
```

```
MAOImprovementPercentage = -6.7905
```

```
% FFT
NFFT = length(y);
Y = fft(y,NFFT);
F = ((0:1/NFFT:1-1/NFFT)*F_s).';
magnitudeY = abs(Y);        % Magnitude of the FFT
phaseY = unwrap(angle(Y));  % Phase of the FFT
frequencyAnalysisPlot(F,magnitudeY,phaseY,NFFT)
legend('$i=1$','$i=2$','$i=3$','$i=4$','$i=5$','interpreter','latex')
```




```
MeanMagValues2 = mean(abs(Y))
```

```
MeanMagValues2 = 1×5
  161.2382   44.3225   64.6400   22.8370   46.2934
```

```
MMVImprovementPercentages = -(MeanMagValues2-MeanMagValues1)*100./MeanMagValues1
```

```
MMVImprovementPercentages = 1×5
  -85.6302   26.4317   10.9650   13.7155    5.9731
```

Plot helper function for the Frequency Analysis

```
function frequencyAnalysisPlot(F,Ymag,Yangle,NFFT,ttlMag,ttlPhase)
    % Copyright 2012 The MathWorks, Inc.
    figure
%     subplot(2,1,1)
    plot(F(1:NFFT/2)/1e3,20*log10(Ymag(1:NFFT/2,:)));
    if nargin > 4 && ~isempty(ttlMag)
      tstr = {'Magnitude Response of the Signal',ttlMag};
    else
      tstr = {'Magnitude response of the Signal'};
    end
    title(tstr)
    xlabel('Frequency in kHz')
    ylabel('dB')
    grid on;
```

```
    axis tight

%     subplot(2,1,2)
%     plot(F(1:NFFT/2)/1e3,Yangle(1:NFFT/2,:));
%     if nargin > 5
%       tstr = {'Phase Response of the Signal',ttlPhase};
%     else
%       tstr = {'Phase Response of the Signal'};
%     end
%     title(tstr)
%     xlabel('Frequency in kHz')
%     ylabel('radians')
%     grid on;
%     axis tight
end
```