Final Report for the Term Project (EE601)

submitted

by

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1 Exp 1: Consensus control of Time Delayed Single Integrator Multi Agent System

1.1 Objectives:

- To achieve consensus for all given leader following and leader less graphs by giving the time delays.
- To design simulation models for leader following and leaderless graphs based on range of time delay criteria.
- Observe the simulation results for the given single integrator multi agent system by giving different range of time delays and find the range of time delay for which system can reach consensus and the range of time delay for which system goes into unstable mode.

1.2 Schematic block diagram

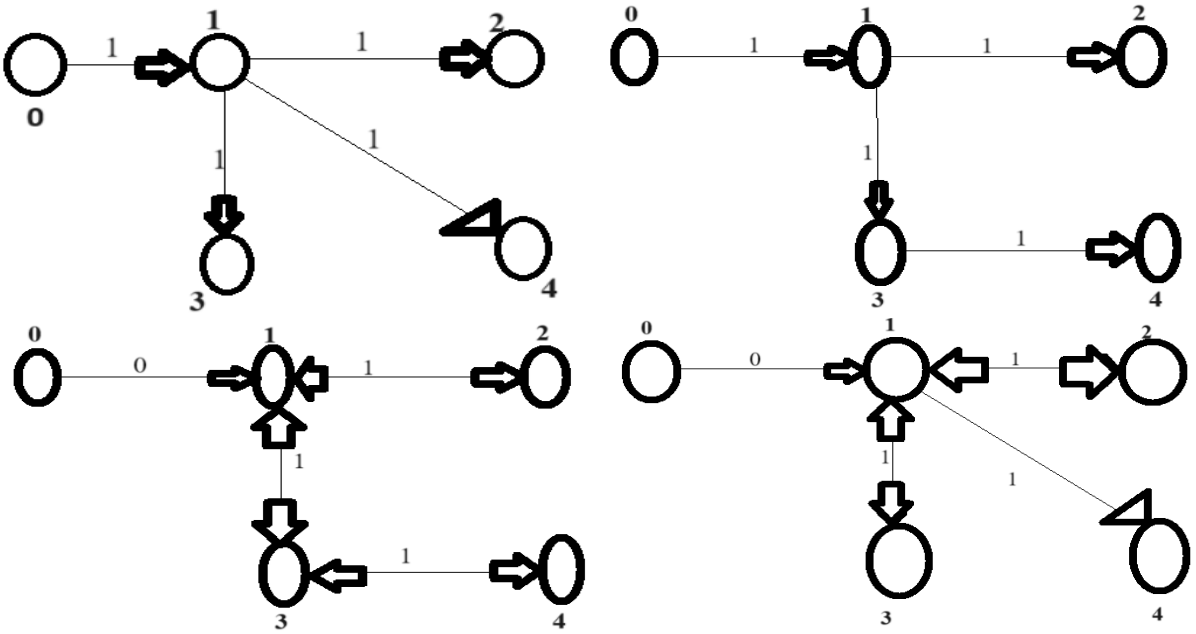

Figure 1: Leader Following graph1 and graph2,Leaderless graph3 and graph4

1.3 Theory

When information is exchanged among agents through communication, time delays associated with both message transmission and processing after receipt must be considered. Time delay plays a major role in justifying whether the system can achieve consensus or not.Here all states from the state feedback controller are delayed by certain amount of time because of time delays associated with message transmission between the agents.If this time delay exceeds the particular range then the system cannot achieve consensus.Range of this time delay can be calculated from the eigen values associated with Laplacian matrices corresponding to the given leader following and leader less graphs.

1.4 Conclusion

The given single integrator multi agent system can achieve consensus only if the time delay corresponding to that particular graph should in the prescribed range. If time delay exceeds its range then the system cannot achieve consensus.

1.5 Matlab Codes,Simulink Diagrams, Simulation Results

2/12/23 12:37 AM C:\U...\EE601_leader_following_graph1.m 1 of 1

```
close all; clear all; clc;
A=0
B=1
C=1
D=0
N=4
n=1;
A_bar=kron(eye(N), A);
B_bar=kron(eye(N), B);
C_bar= kron(eye(N), C);
D_bar=kron(eye(N), D);
Cf=eye(n);
Cf_bar=kron(eye(N), Cf);
Df=[0];
Df_bar=kron(eye(N), Df);
Q=1; R=1;
K=lqr(A, B, Q, R);
L=[0 0 0 0;-1 1 0 0;-1 0 1 0;-1 0 0 1];
P=[1 0 0 0; 0 0 0 0;0 0 0 0;0 0 0 0];
Acl_bar=A_bar-kron((L+P), B*K);
eig(Acl_bar)
eig(L)
```


Figure 2: Matlab Code for Leader Following Graph1

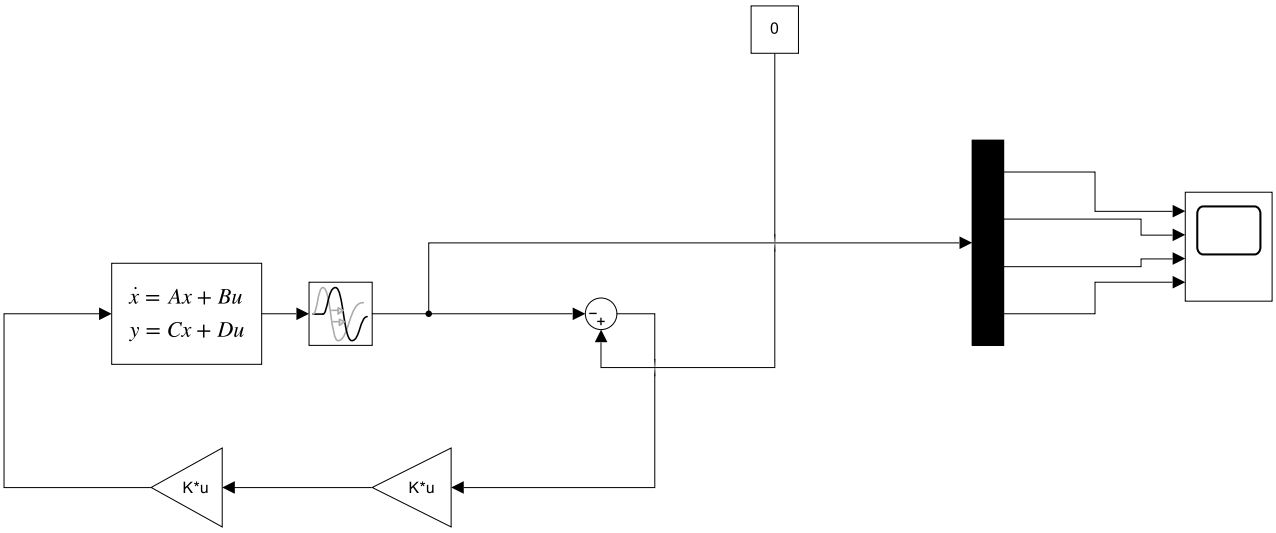

Figure 3: Simulink block diagram for Leader Following Graph1

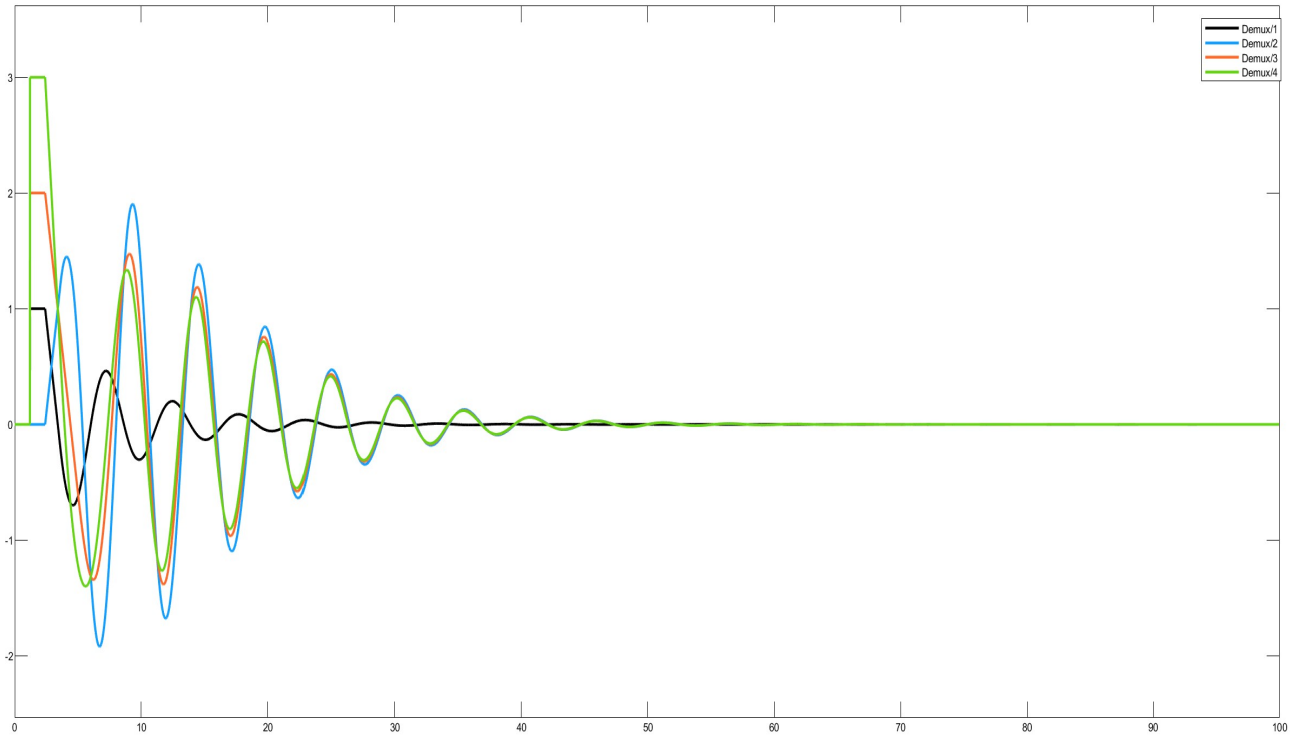

Figure 4: Stable simulink Results for

$$0 < T < 1.57$$

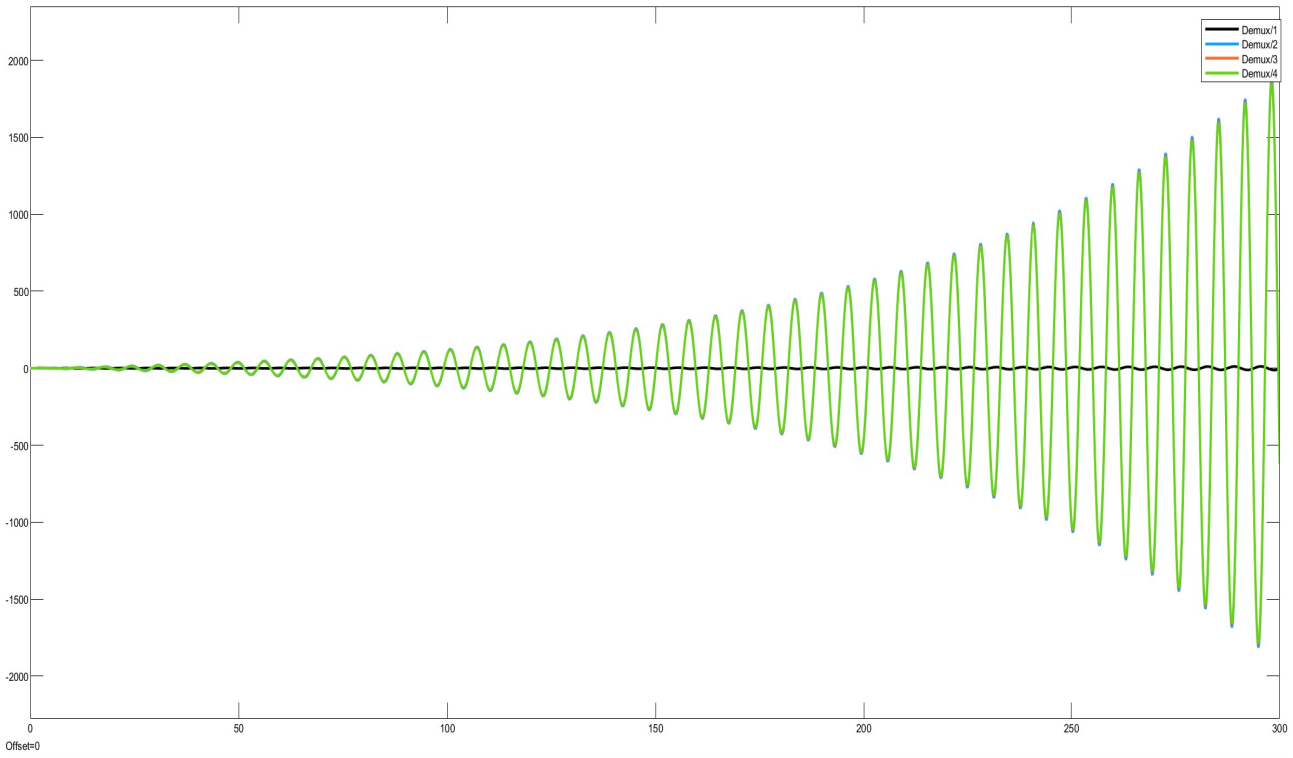

Figure 5: Unstable Simulink Results for $T > 1.57$

```
close all; clear all; clc;
A=0
B=1
C=1
D=0
N=4
n=1;
A_bar=kron(eye(N), A);
B_bar=kron(eye(N), B);
C_bar= kron(eye(N), C);
D_bar=kron(eye(N), D);
Cf=eye(n);
Cf_bar=kron(eye(N), Cf);
Df=[0];
Df_bar=kron(eye(N), Df);
Q=1; R=1;
K=lqr(A, B, Q, R);
L=[0 0 0 0;-1 1 0 0;-1 0 1 0;0 0 -1 1];
P=[1 0 0 0; 0 0 0 0;0 0 0 0;0 0 0 0];
Acl_bar=A_bar-kron((L+P), B*K);
eig(Acl_bar)
eig(L)
```

Figure 6: Matlab Code for Leader Following Graph2

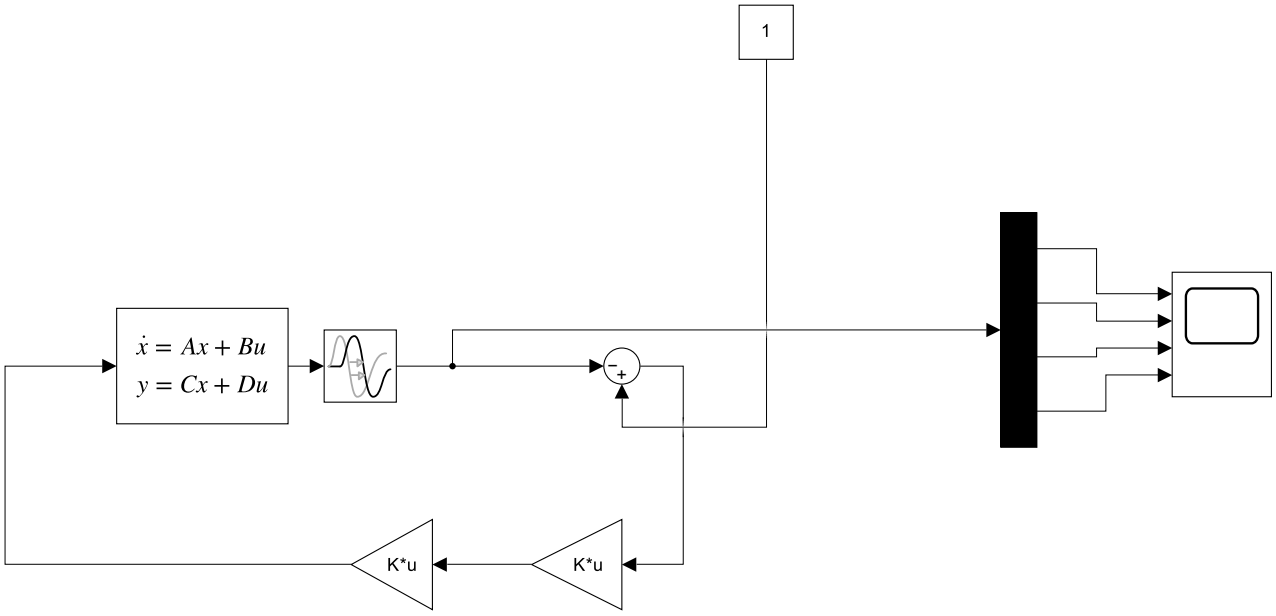

Figure 7: Simulink block diagram for Leader Following Graph2

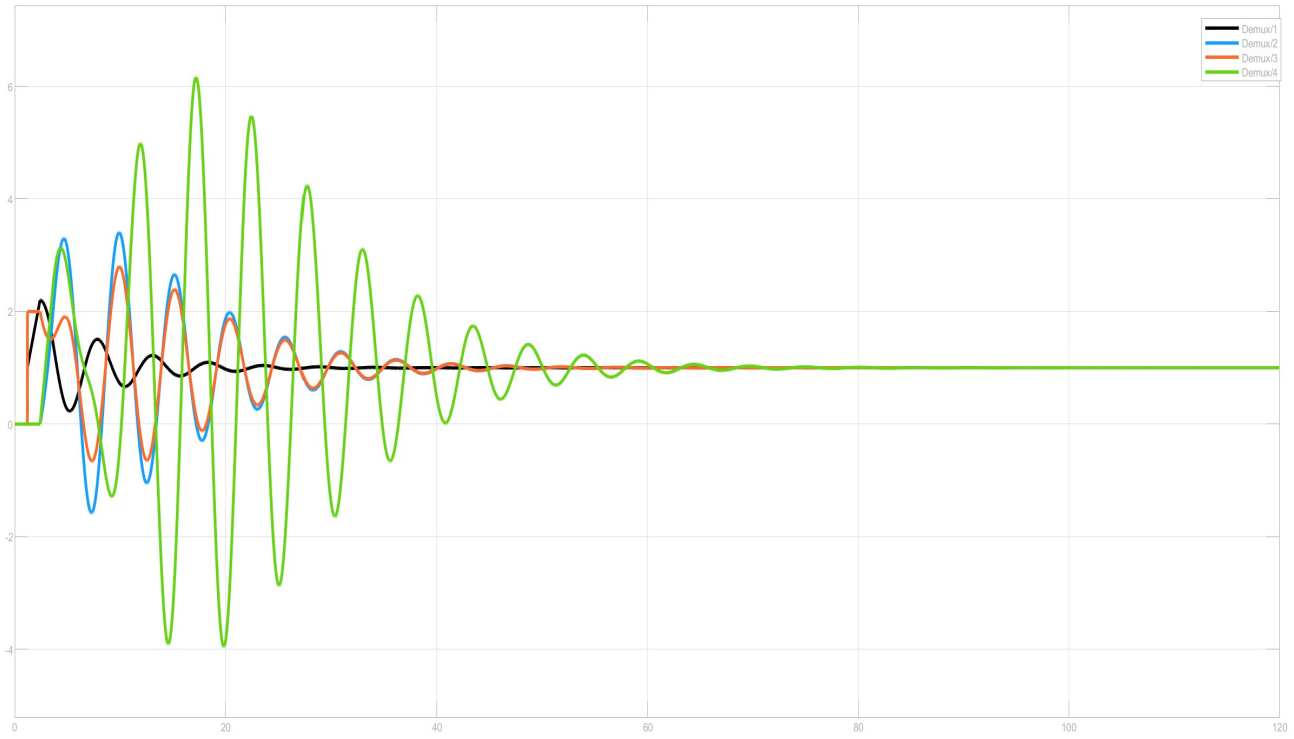

Figure 8: Stable simulink Results for

$$0 < T < 1.57$$

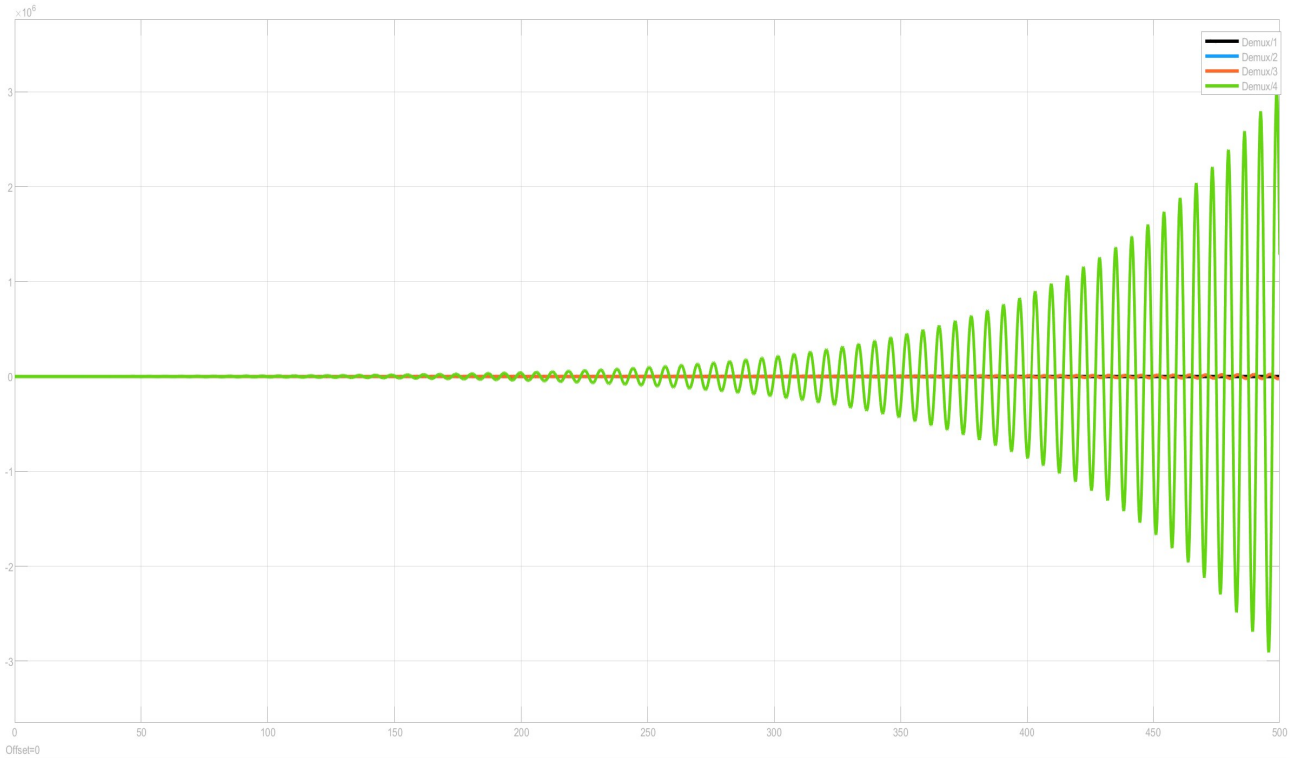

Figure 9: Unstable Simulink Results for $T > 1.57$

```
close all; clear all; clc;
A=0
B=1
C=1
D=0
N=4
n=1;
A_bar=kron(eye(N), A);
B_bar=kron(eye(N), B);
C_bar= kron(eye(N), C);
D_bar=kron(eye(N), D);
Cf=eye(n);
Cf_bar=kron(eye(N), Cf);
Df=[0];
Df_bar=kron(eye(N), Df);
Q=1; R=1;
K=lqr(A, B, Q, R)
L=[2 -1 -1 0;-1 1 0 0;-1 0 2 -1;0 0 -1 1];
P=[0 0 0 0; 0 0 0 0;0 0 0 0;0 0 0 0];
Acl_bar=A_bar-kron((L+P), B*K);
eig(Acl_bar)
eig(L)
```

Figure 10: Matlab Code for Leader Following Graph3

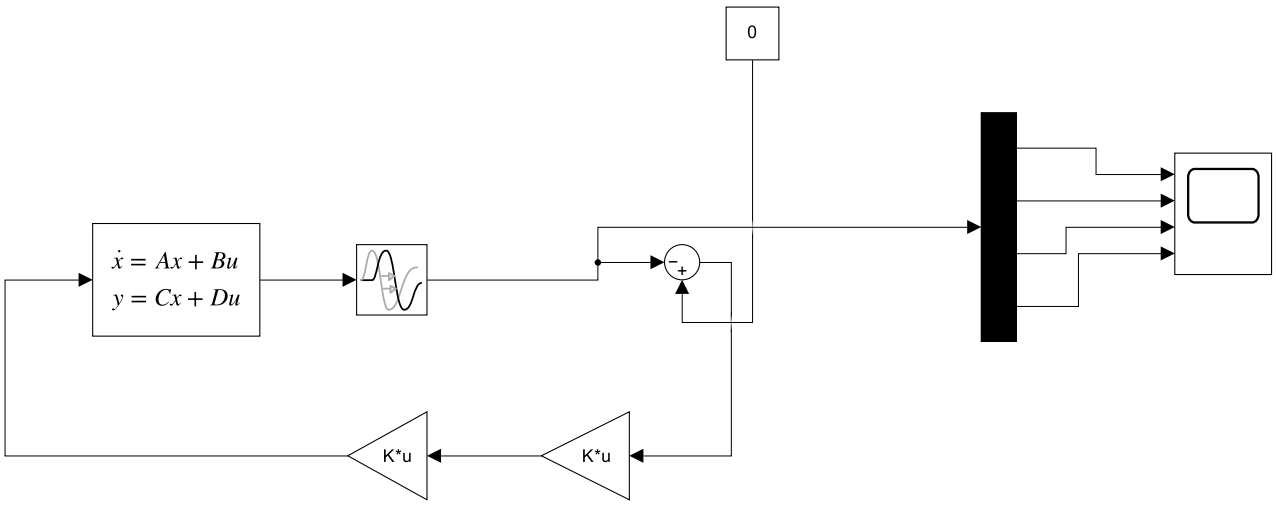

Figure 11: Simulink block diagram for Leader Following Graph3

Figure 12: Stable simulink Results for

$$0 < T < 0.4598$$

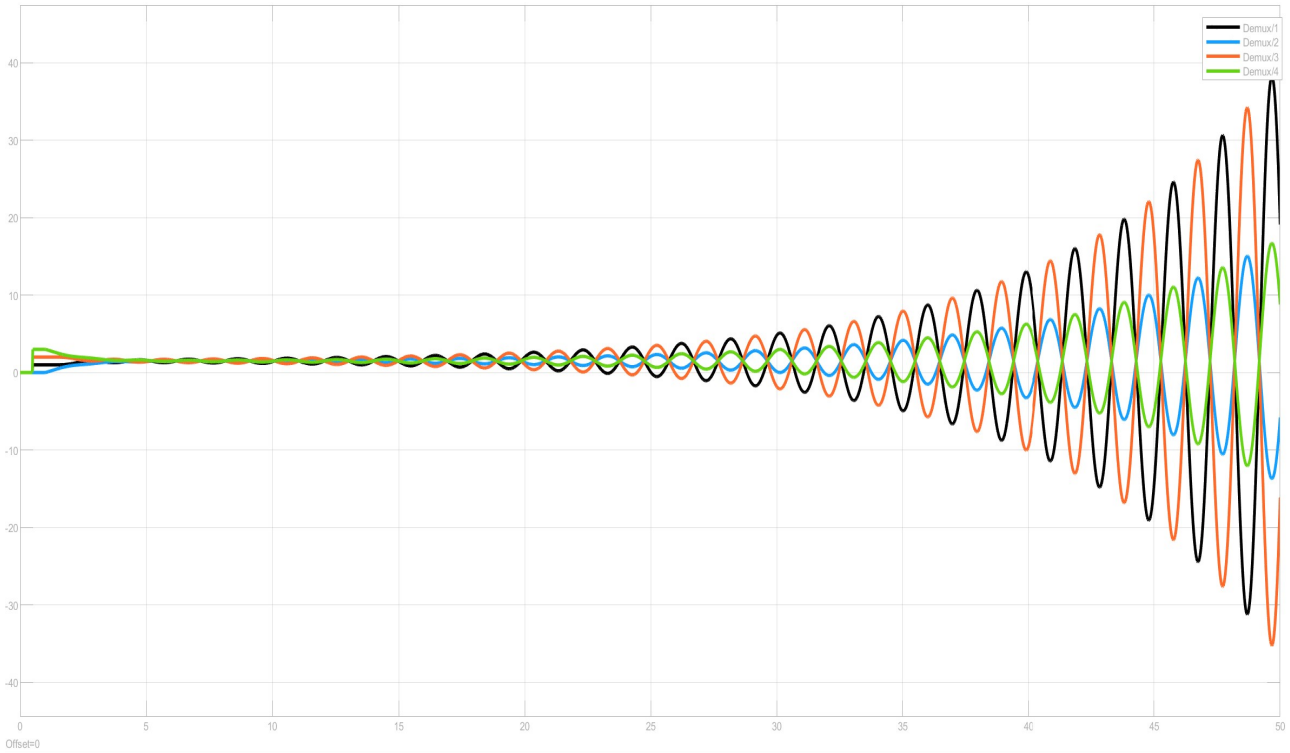

Figure 13: Unstable Simulink Results for $T > 0.4598$

```
close all; clear all; clc;
A=0
B=1
C=1
D=0
N=4
n=1;
A_bar=kron(eye(N), A);
B_bar=kron(eye(N), B);
C_bar= kron(eye(N), C);
D_bar=kron(eye(N), D);
Cf=eye(n);
Cf_bar=kron(eye(N), Cf);
Df=[0];
Df_bar=kron(eye(N), Df);
Q=1; R=1;
K=lqr(A, B, Q, R);
L=[3 -1 -1 -1;-1 1 0 0;-1 0 1 0;-1 0 0 1];
P=[0 0 0 0; 0 0 0 0;0 0 0 0;0 0 0 0];
Acl_bar=A_bar-kron((L+P), B*K);
eig(Acl_bar)
eig(L)
```

Figure 14: Matlab Code for Leader Following graph4

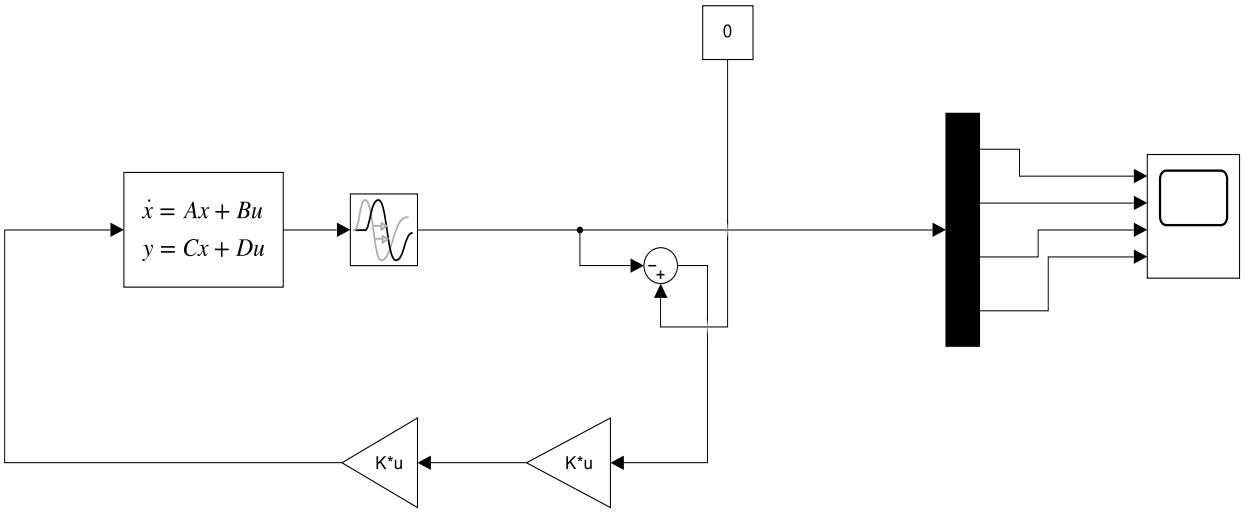

Figure 15: Simulink block diagram for Leader Following Graph4

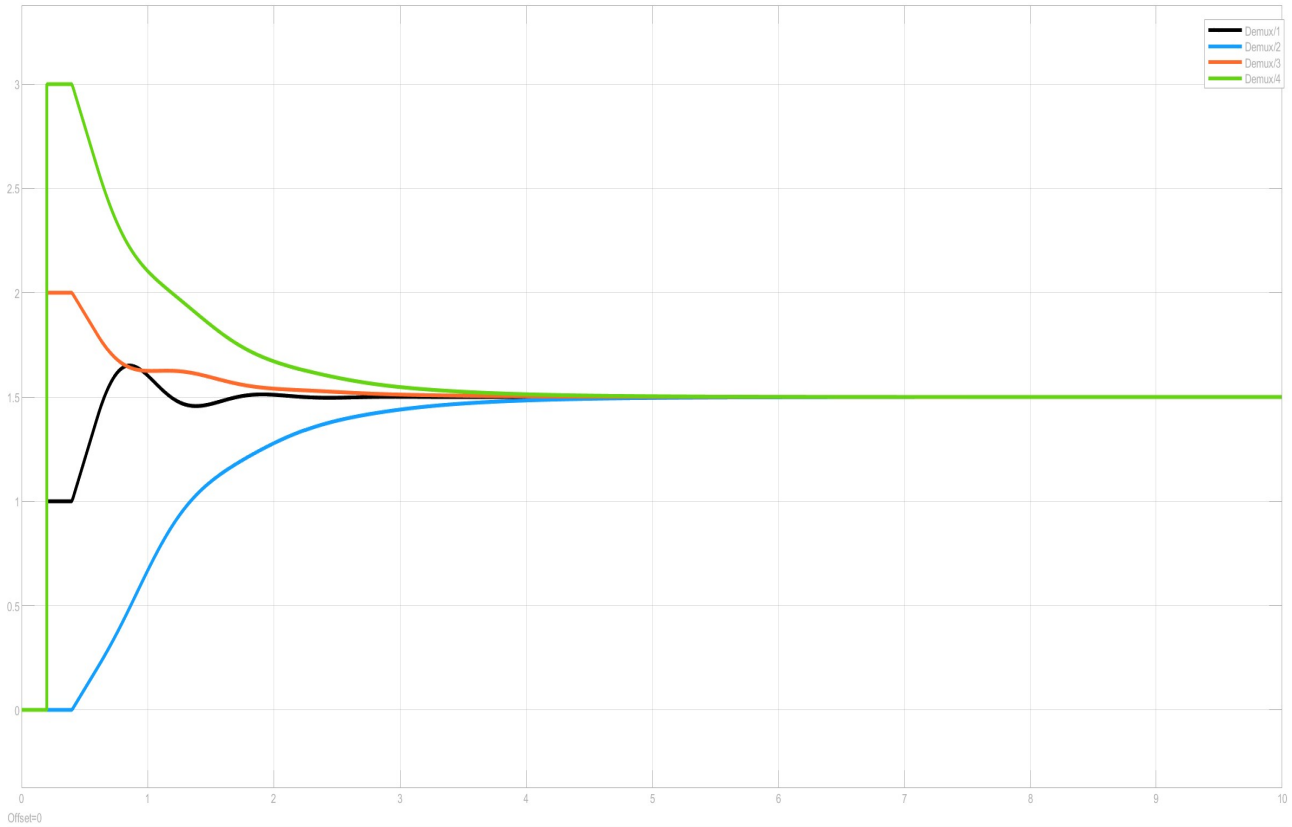

Figure 16: Stable simulink Results for

$$0 < T < 0.3925$$

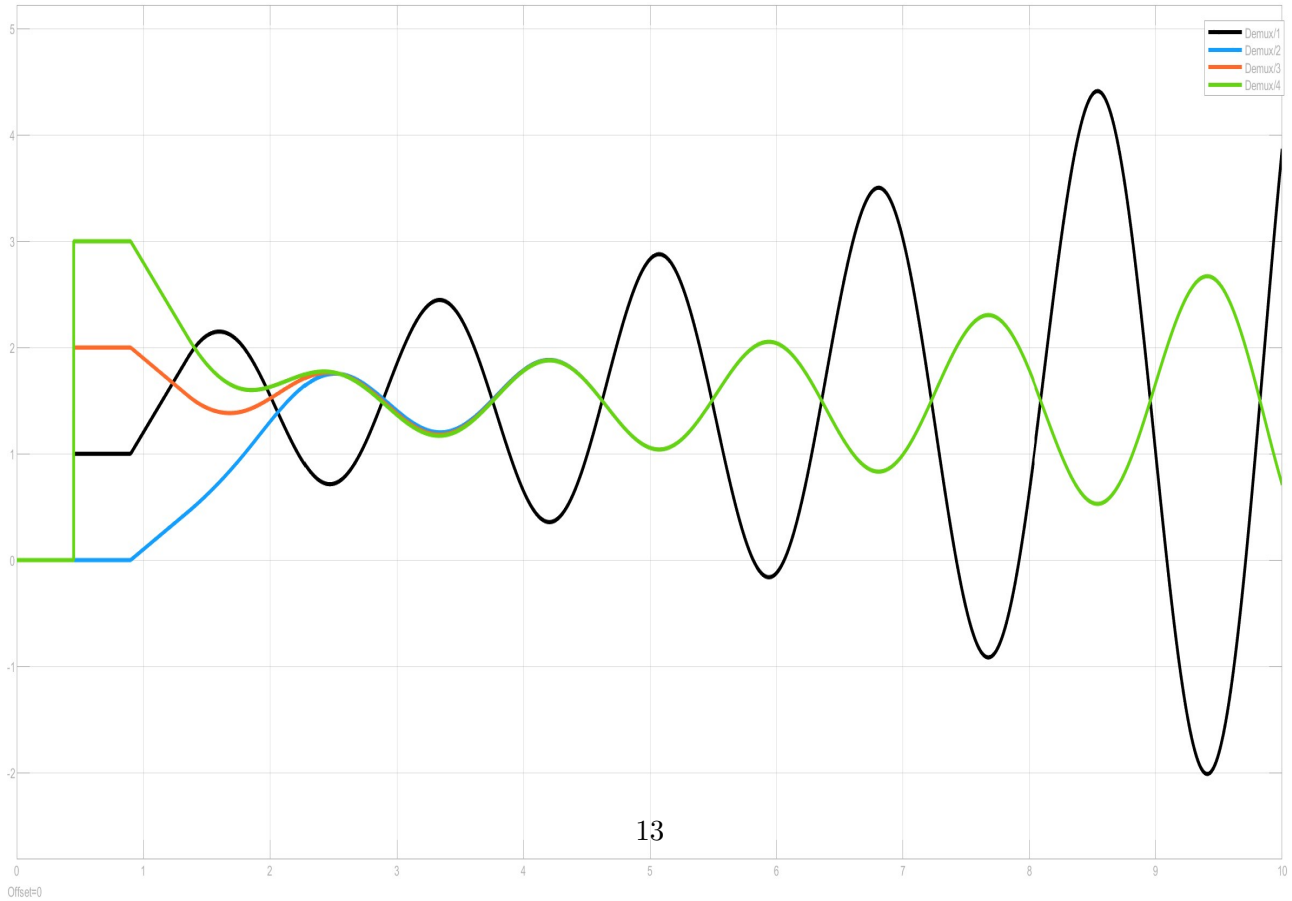

Figure 17: Unstable Simulink Results for $T > 0.3925$