THE UNIVERSITY OF TEXAS AT ARLINGTON, TEXAS
DEPARTMENT OF ELECTRICAL ENGINEERING

EE 5327 - 001

SYSTEM IDENTIFICATION & ESTIMATION

Project #2
EXAM

by

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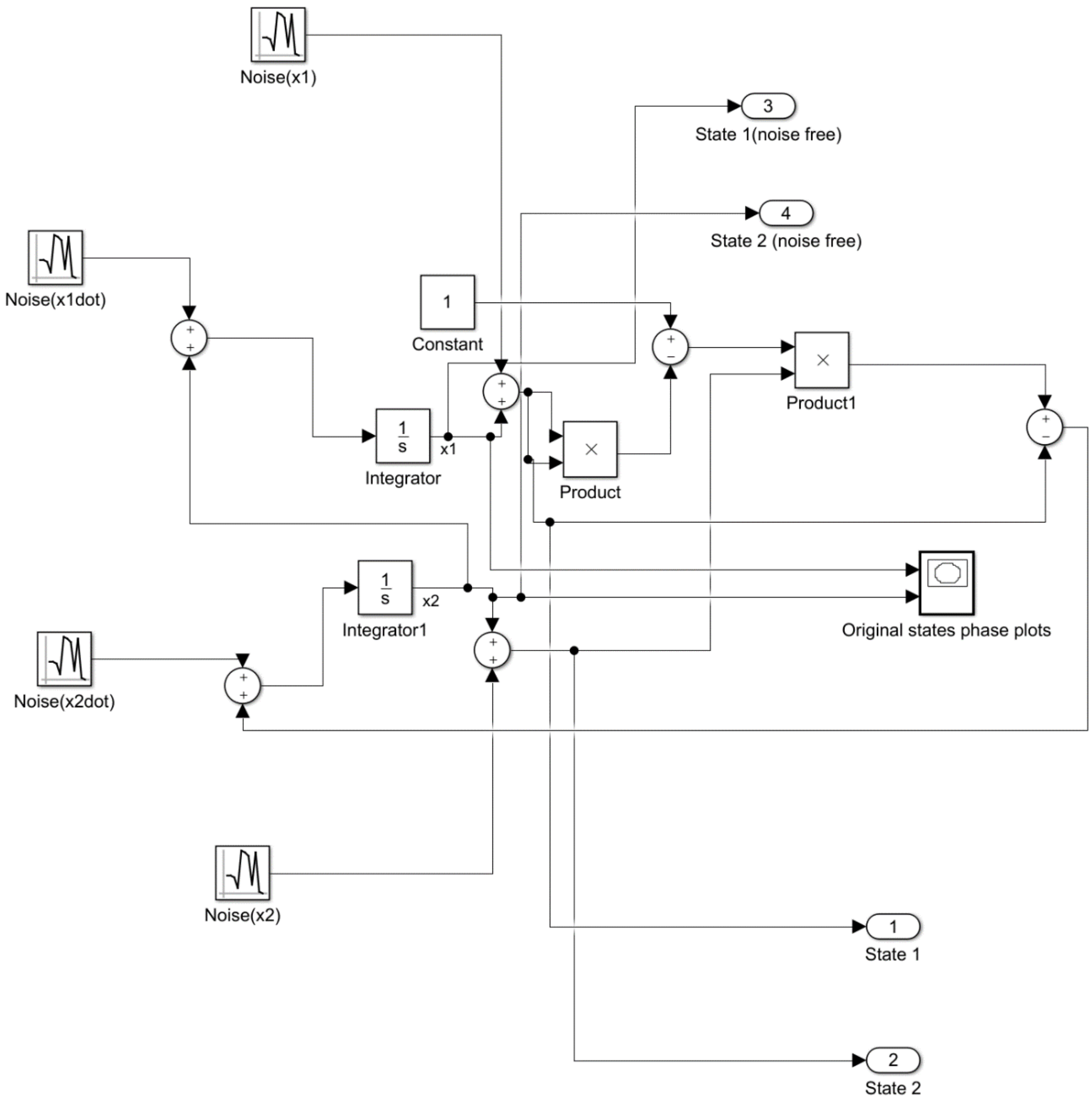
Presented to

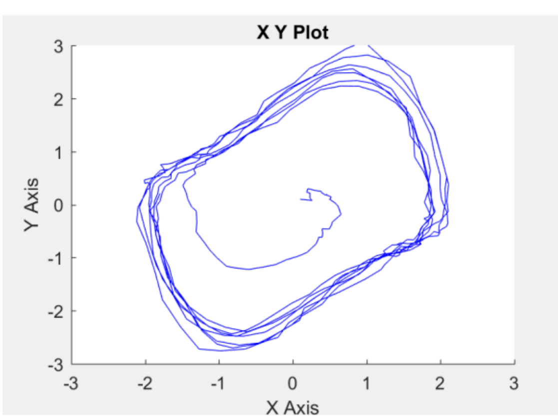
Prof. Michael Niestroy

Dec 15th, 2017

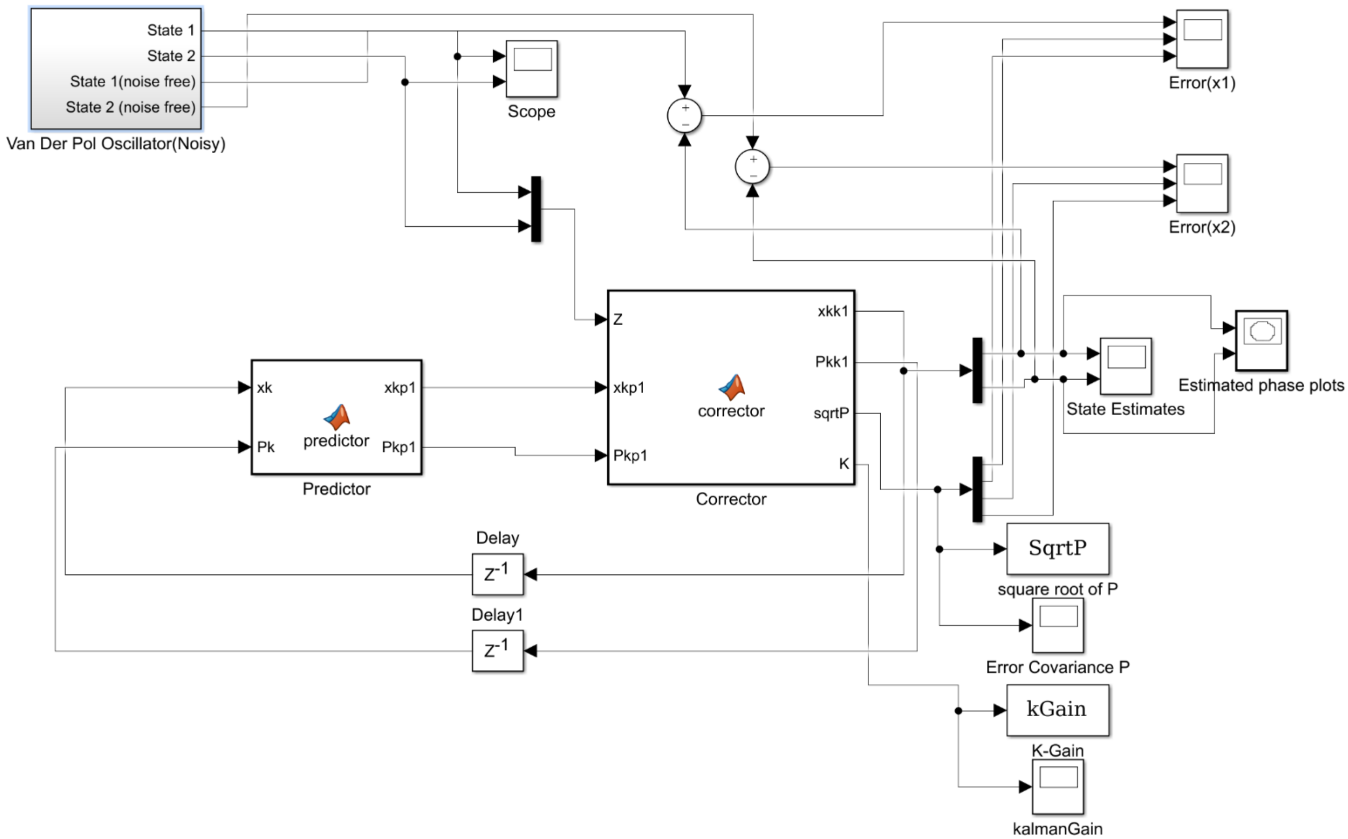
According to the state space equations, the sub system containing the Van Der Pol Oscillator is as follows:



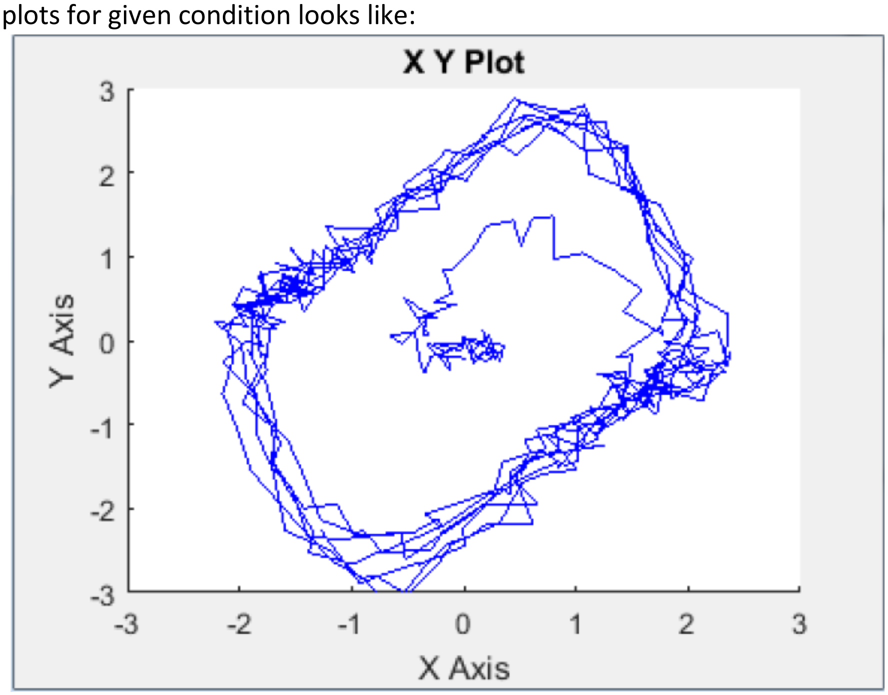
The phase plot of the states when the above block runs is as follows:



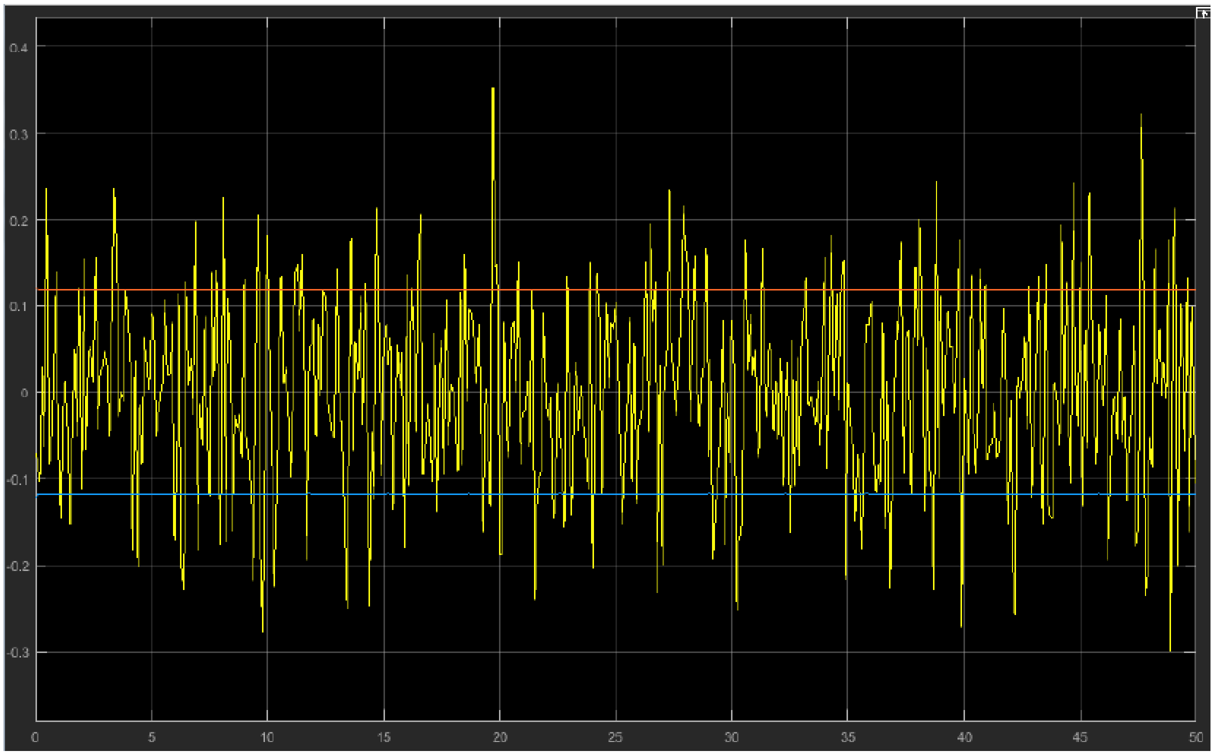
The overall model with the extended Kalman Filter is as follows :

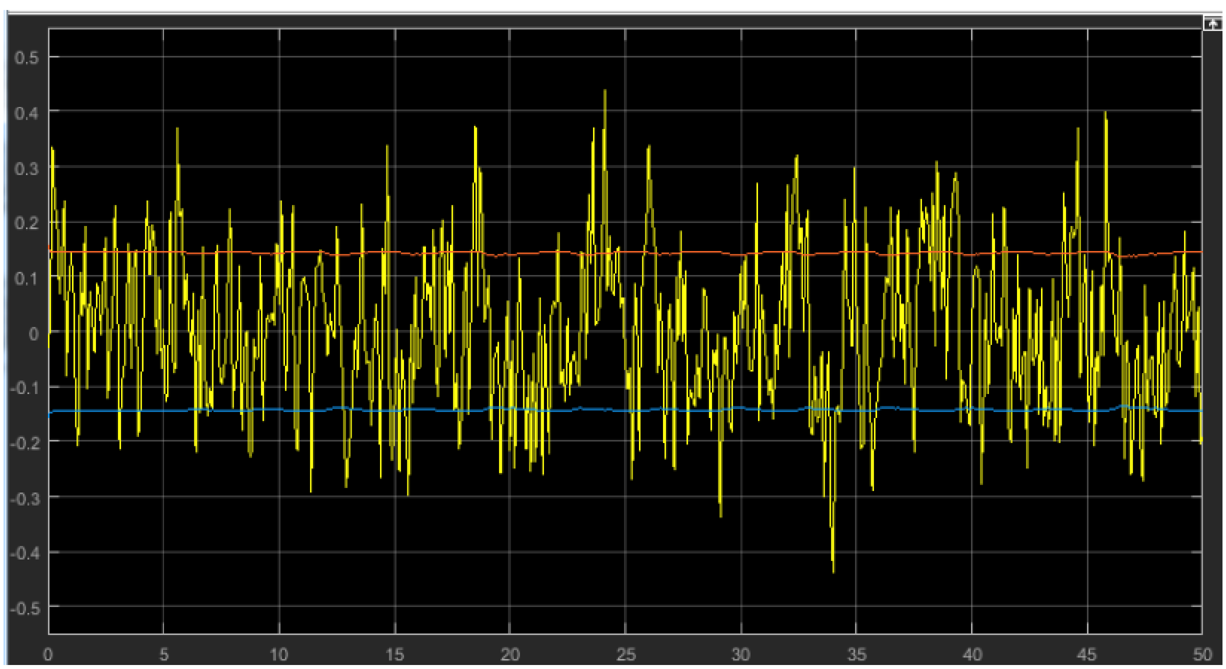


a) When R= diag([0.015 0.025])
Q=diag([2 1])
The phase plots for given condition looks like:

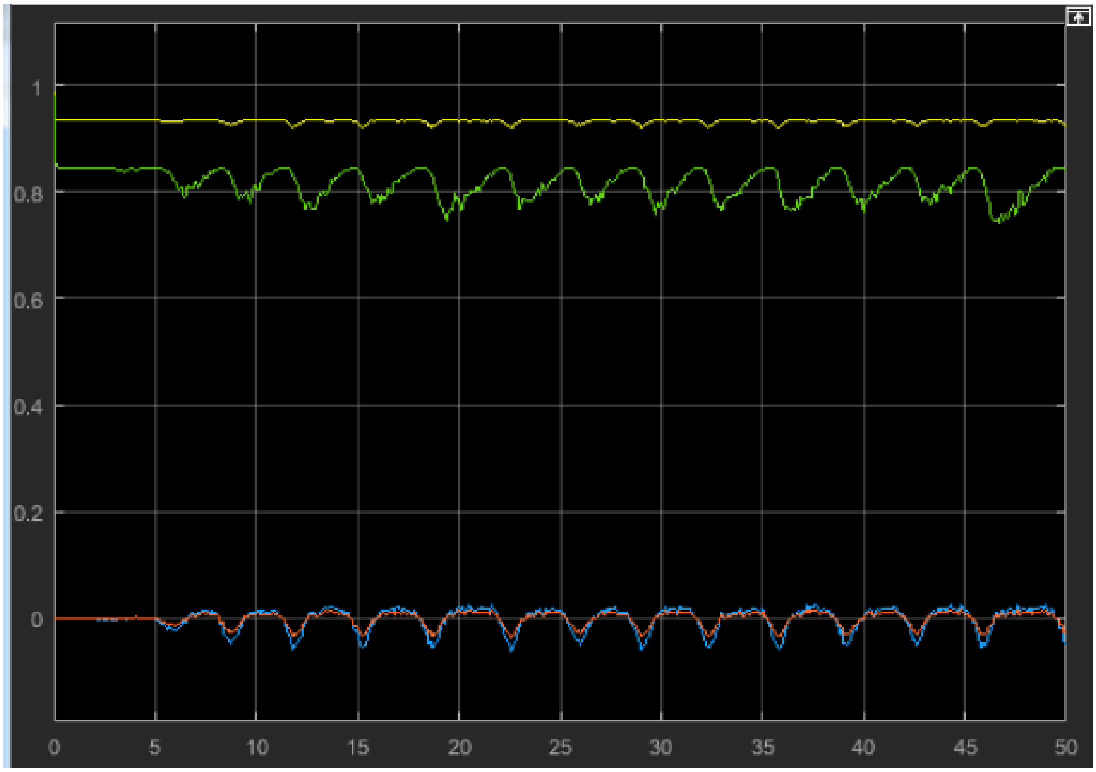


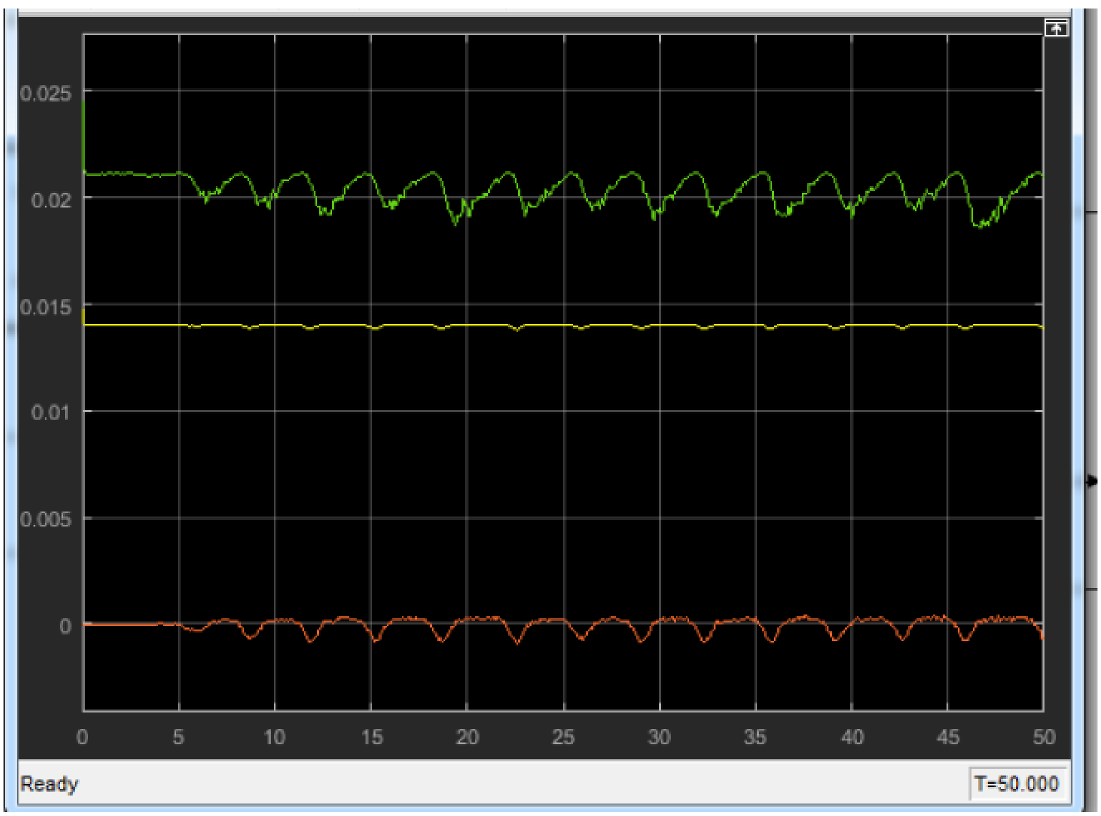
For error and covariance of state 1 and state 2:





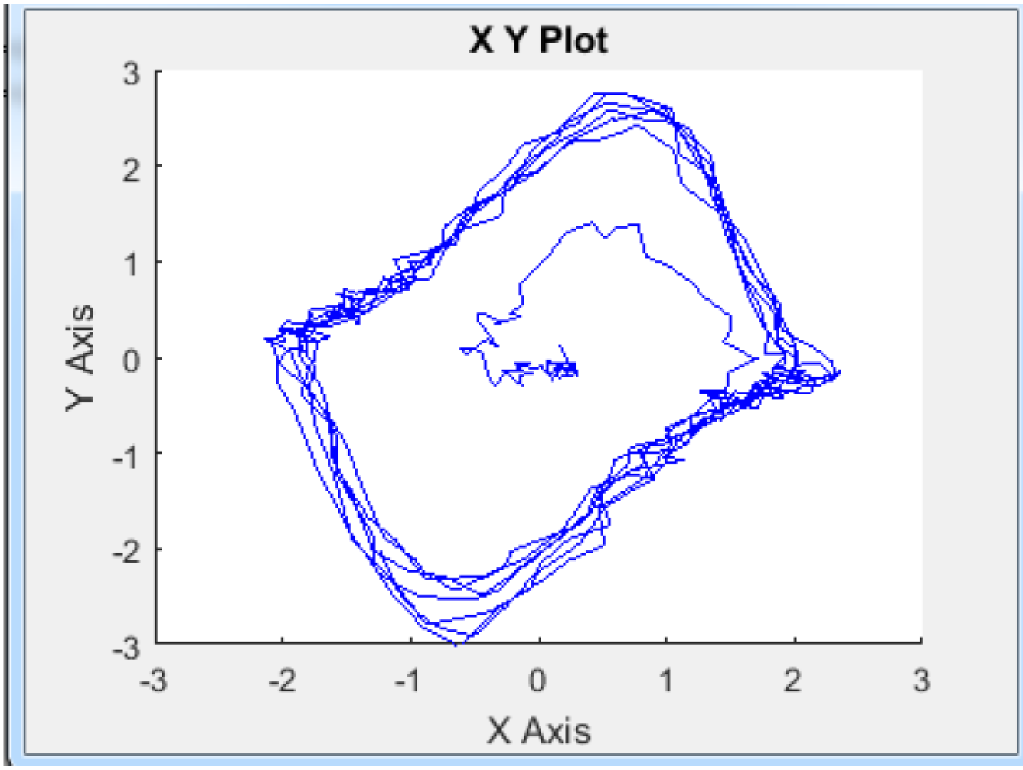
The values of Kalman gain k and error covariance, P:



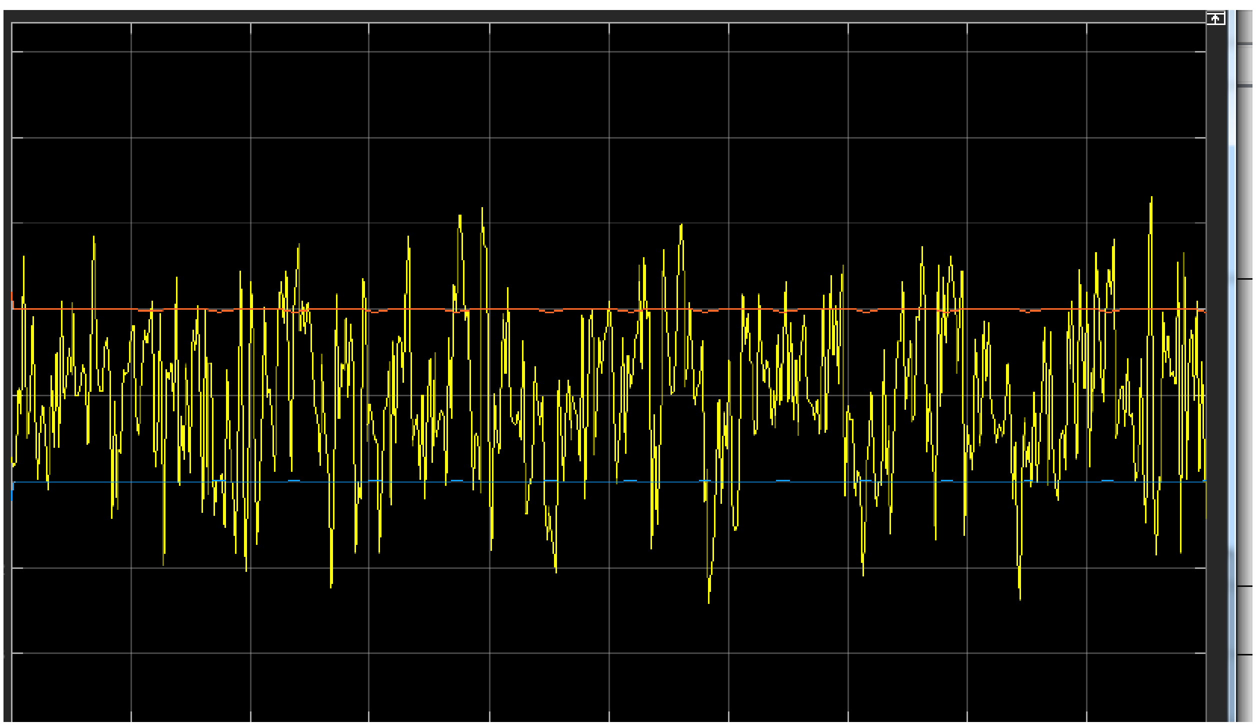


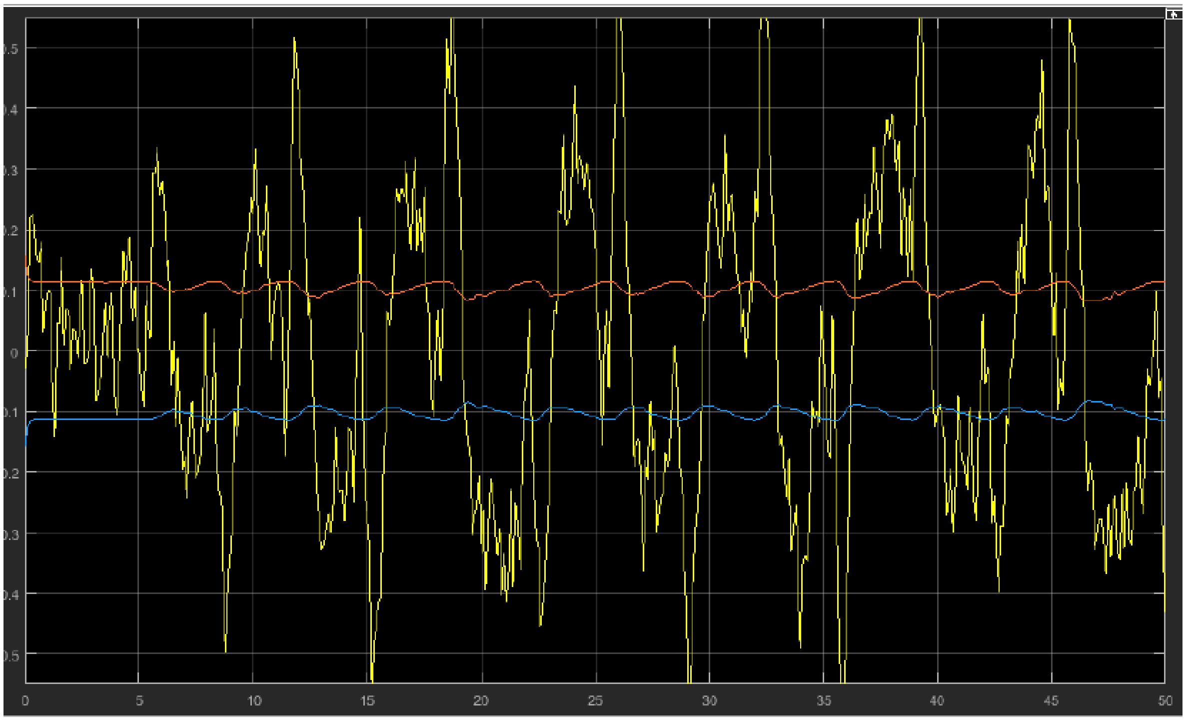
b) When Q = diag([0.2 0.1])

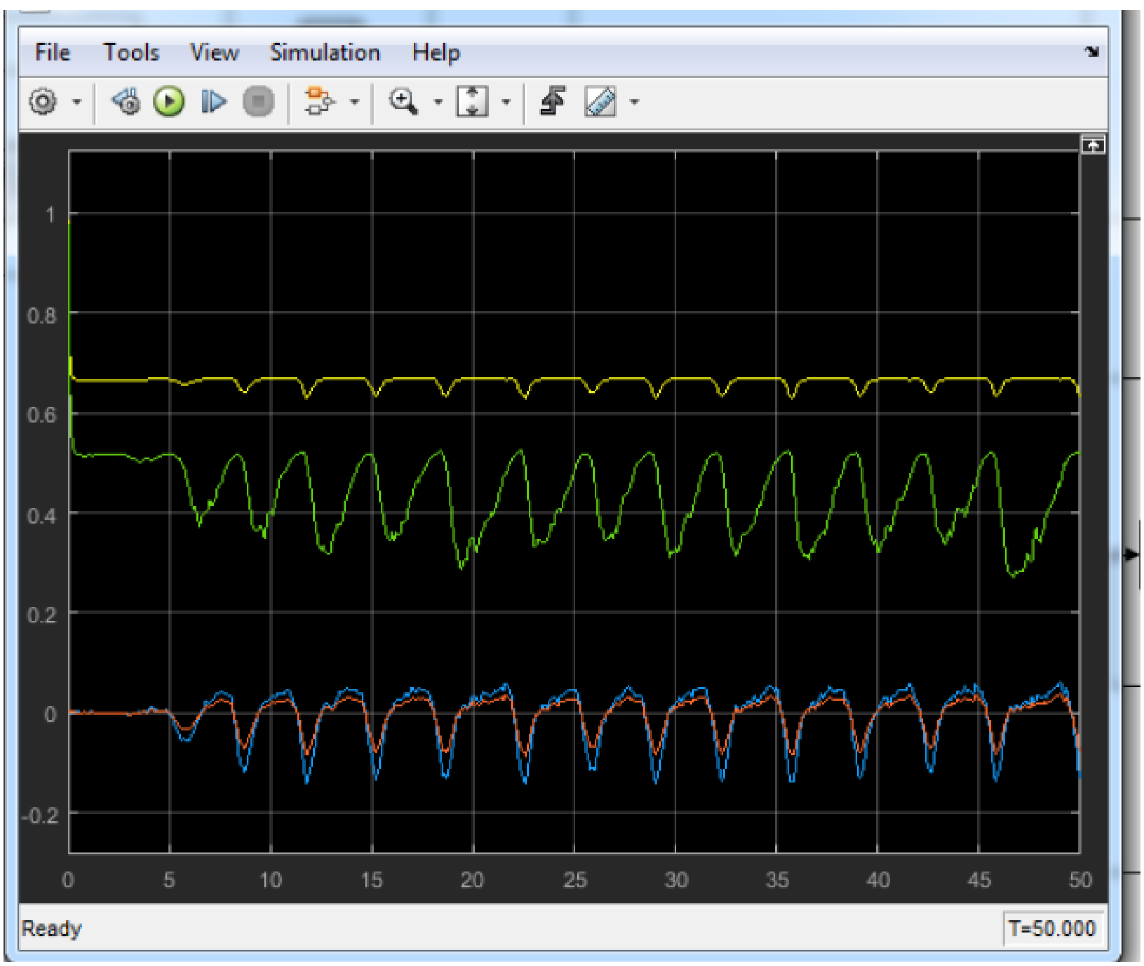
The phase plots for given condition looks like:

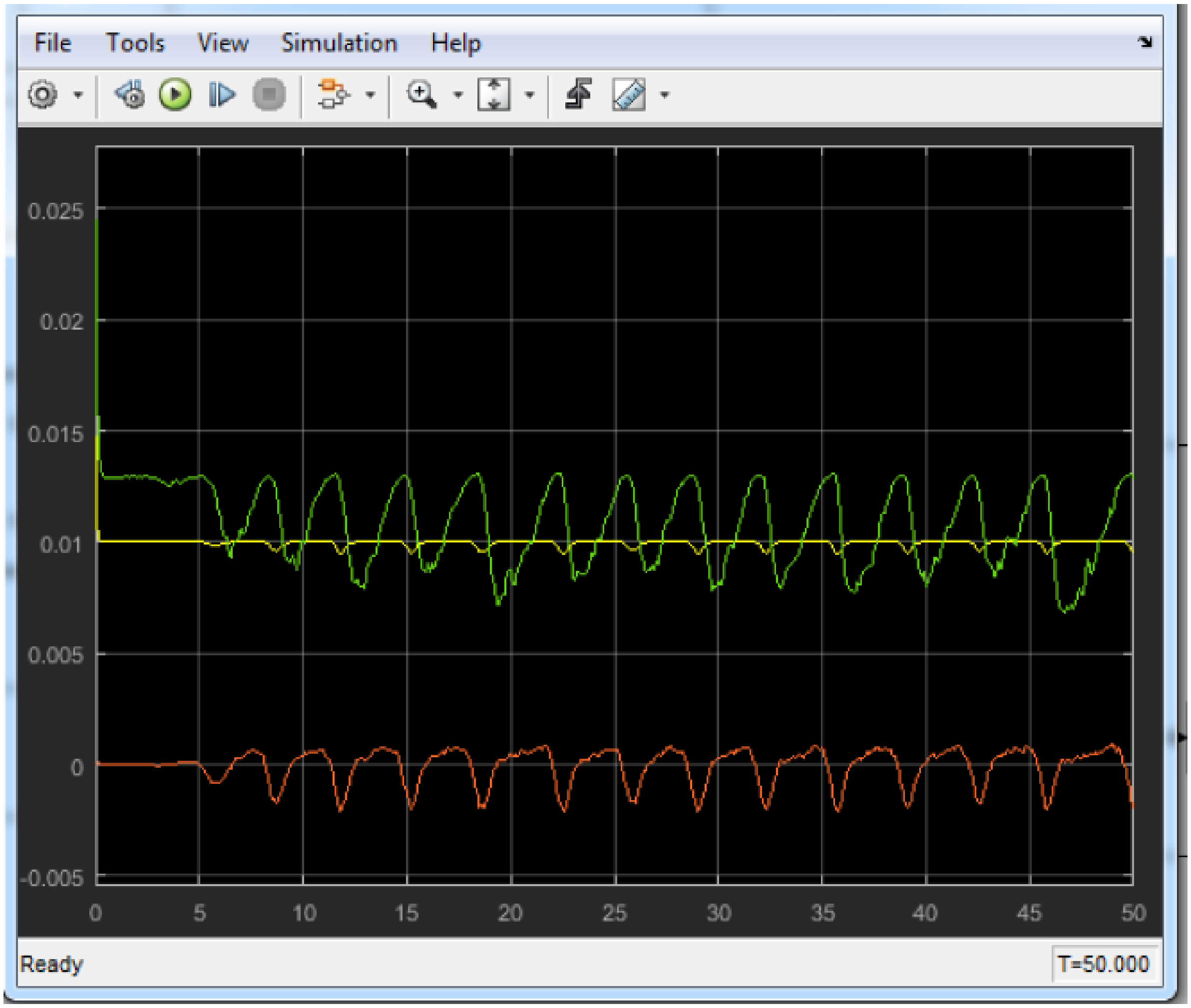


For error and covariance of state 1 and state 2:



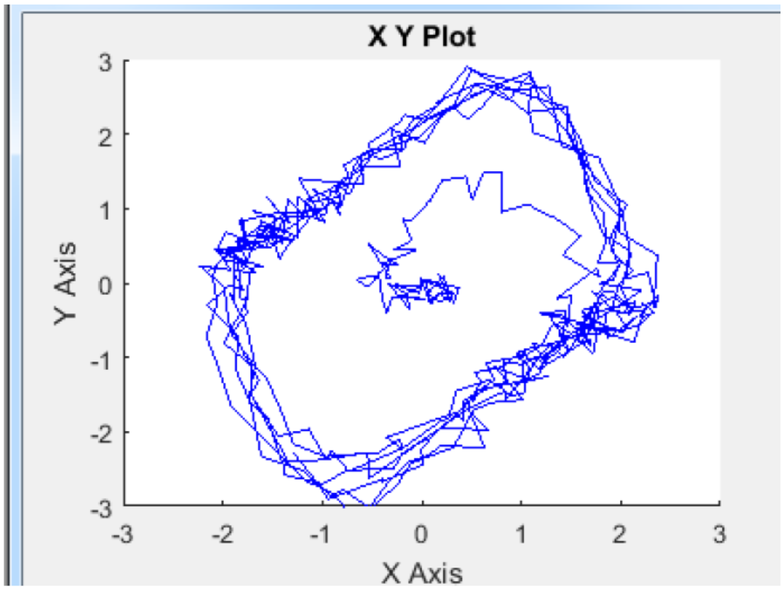

0
5
10
15
20
25
30
35
40
45
50


File
Tools
View
Simulation
Help
1
0.8
0.6
0.4
0.2
0
-0.2
0
5
10
15
20
25
30
35
40
45
50
Ready
T=50.000

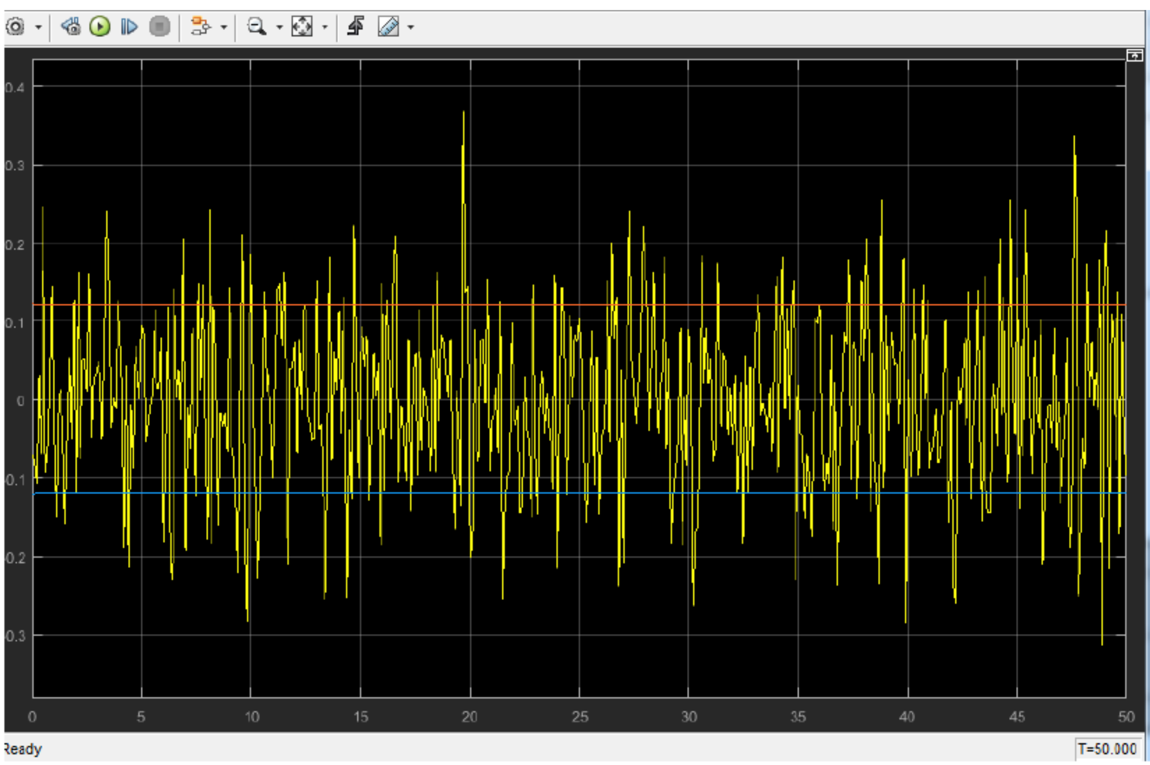


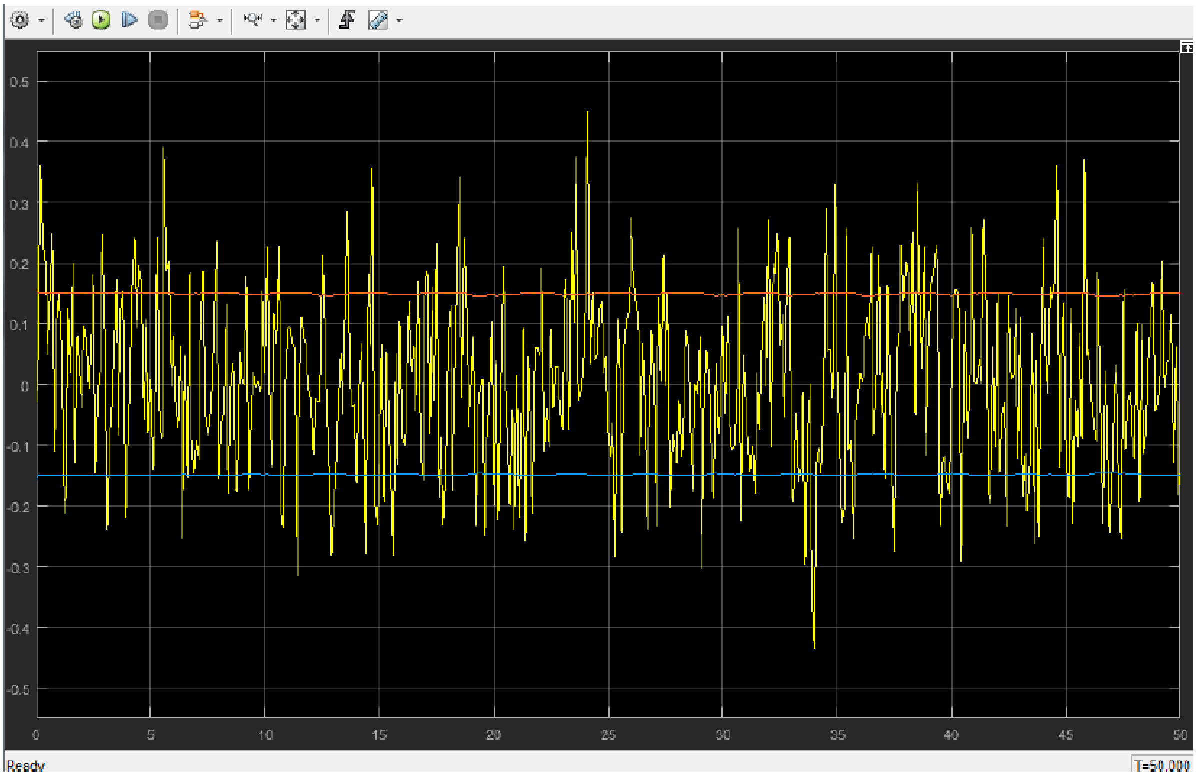
When Q = diag([4 2])

The phase plots for given condition looks like:

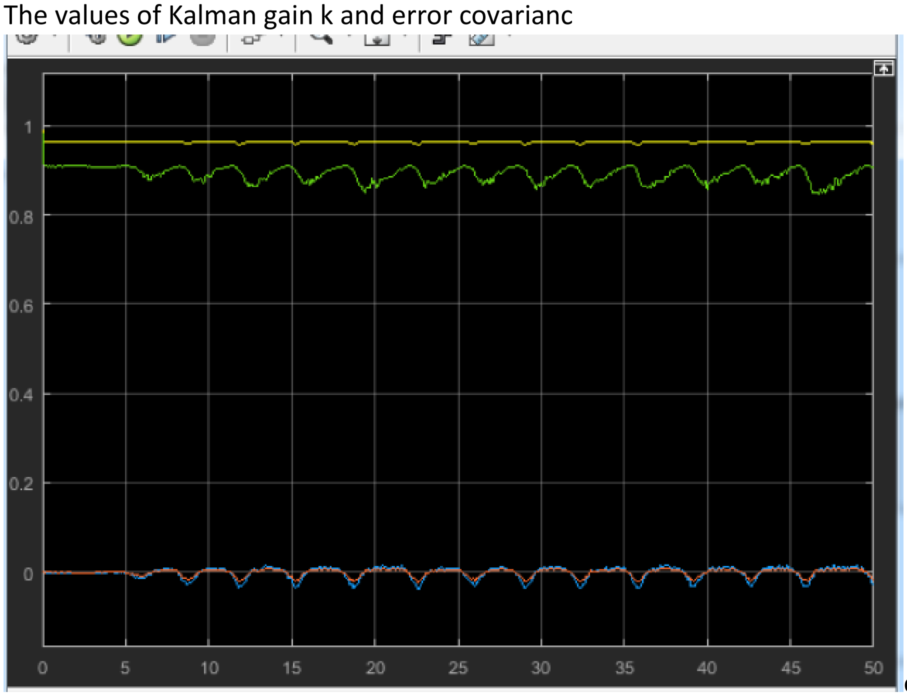


For error and covariance of state 1 and state 2:

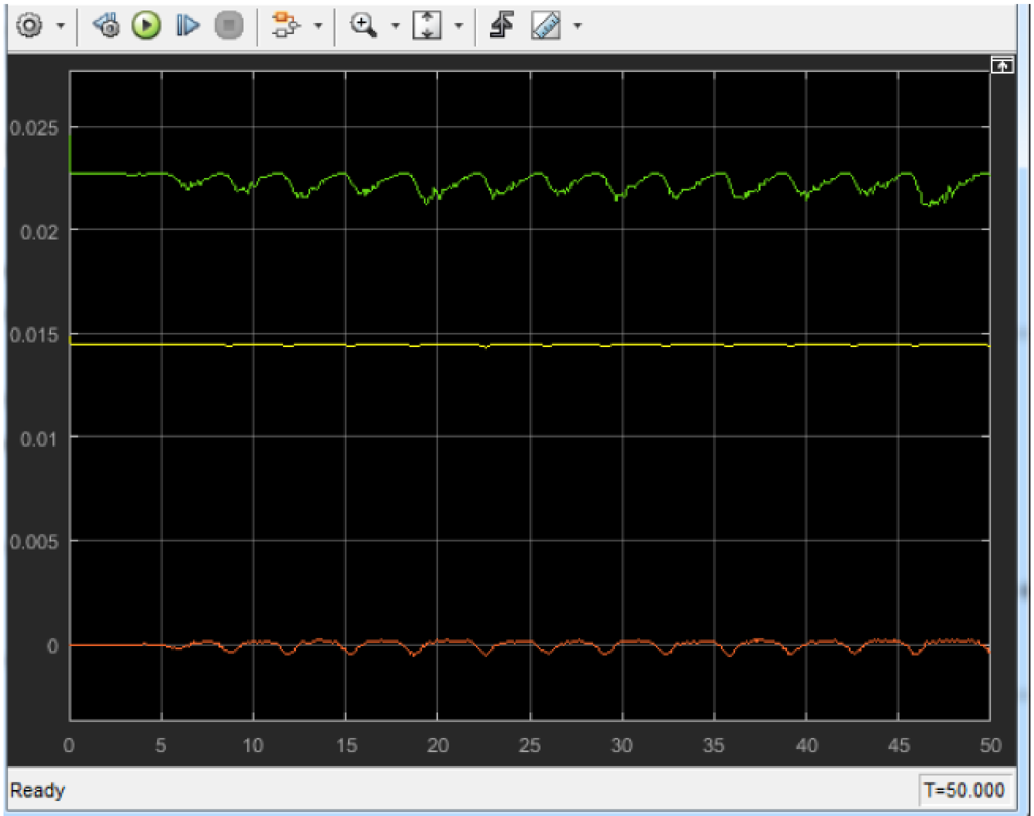




The values of Kalman gain k and error covarianc



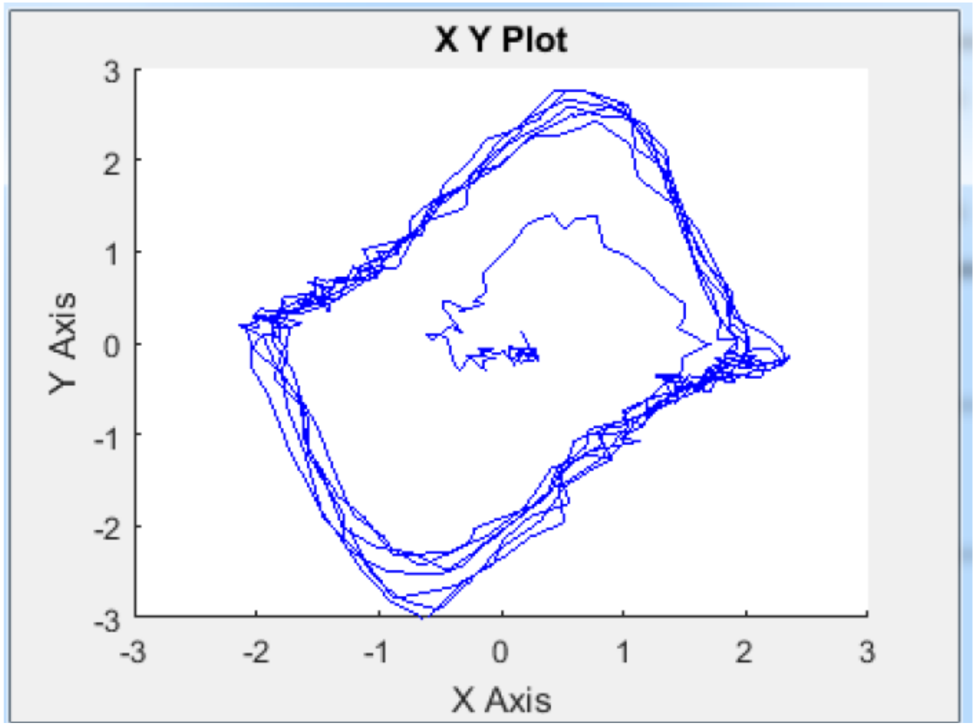
e, P:



When Q is changed to diag([4 2]), the estimates are better for the states. There is considerably less spikes in error of state 2 as can be seen from the above plots.

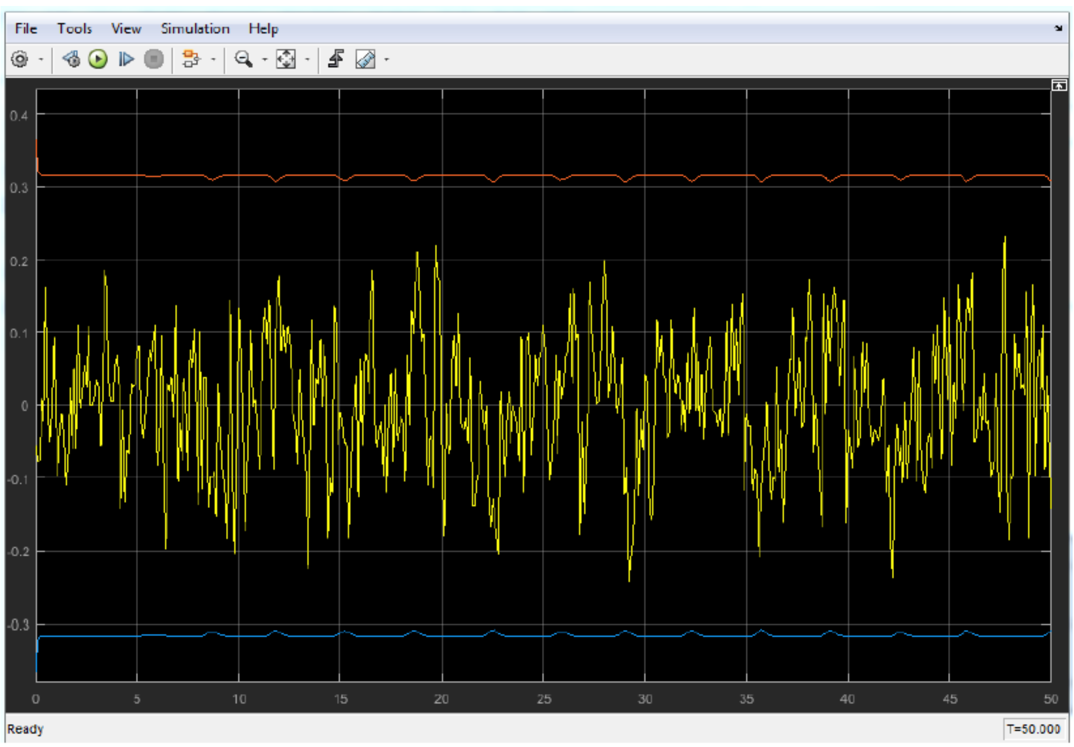
c) When Q = dia([2 1]) and R = diag([0.15 0.25])

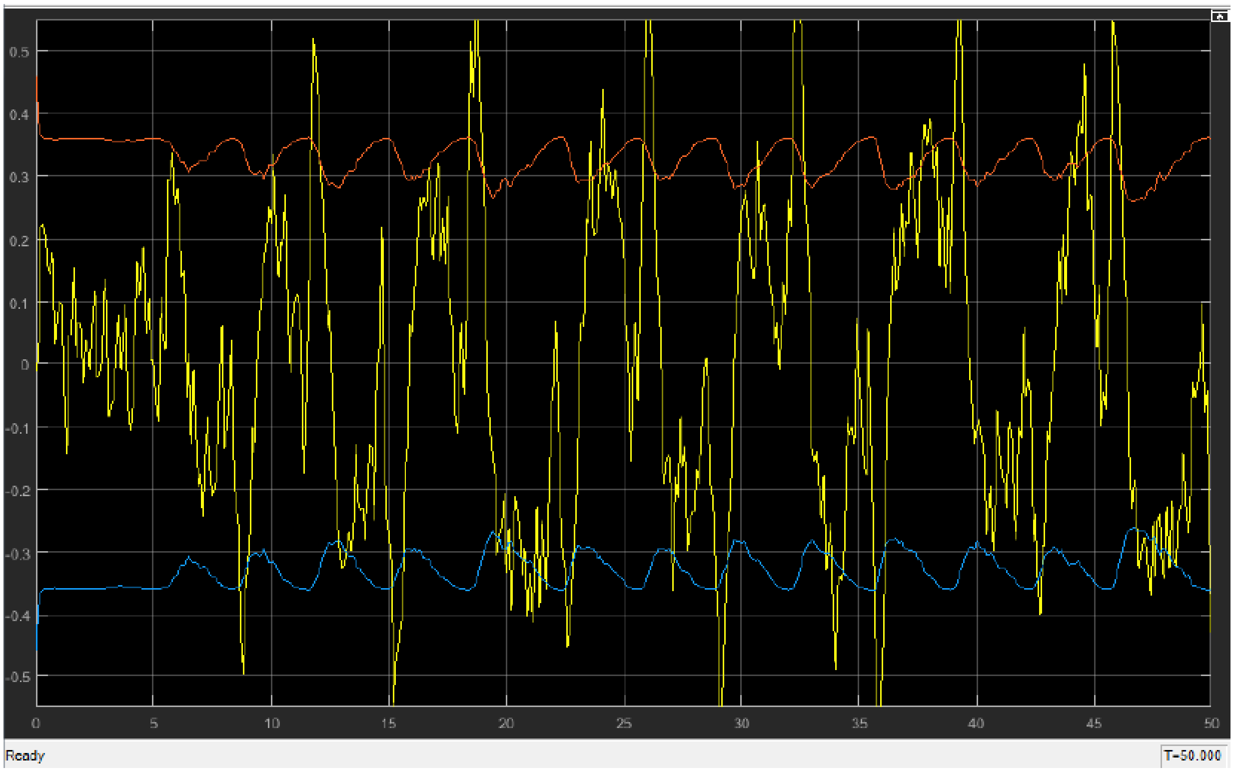
The phase plots for given condition looks like



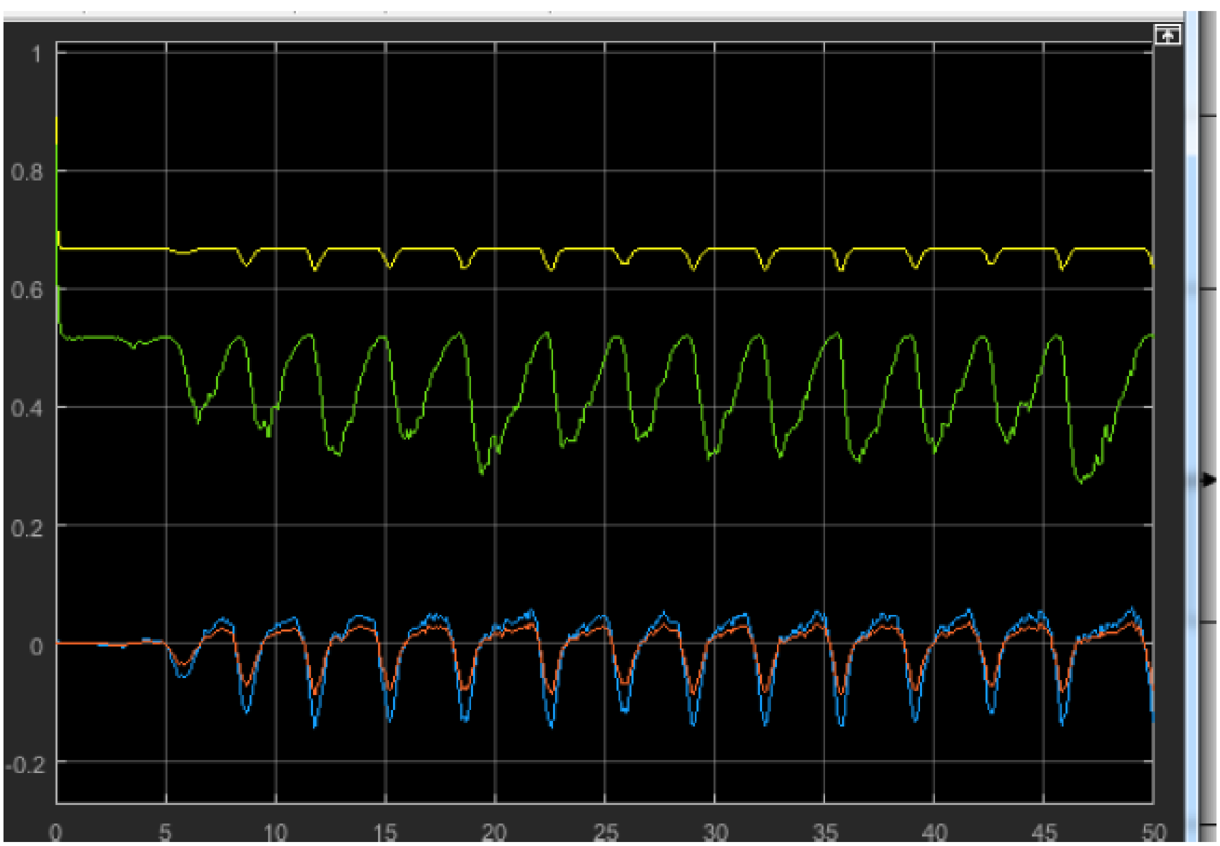
:

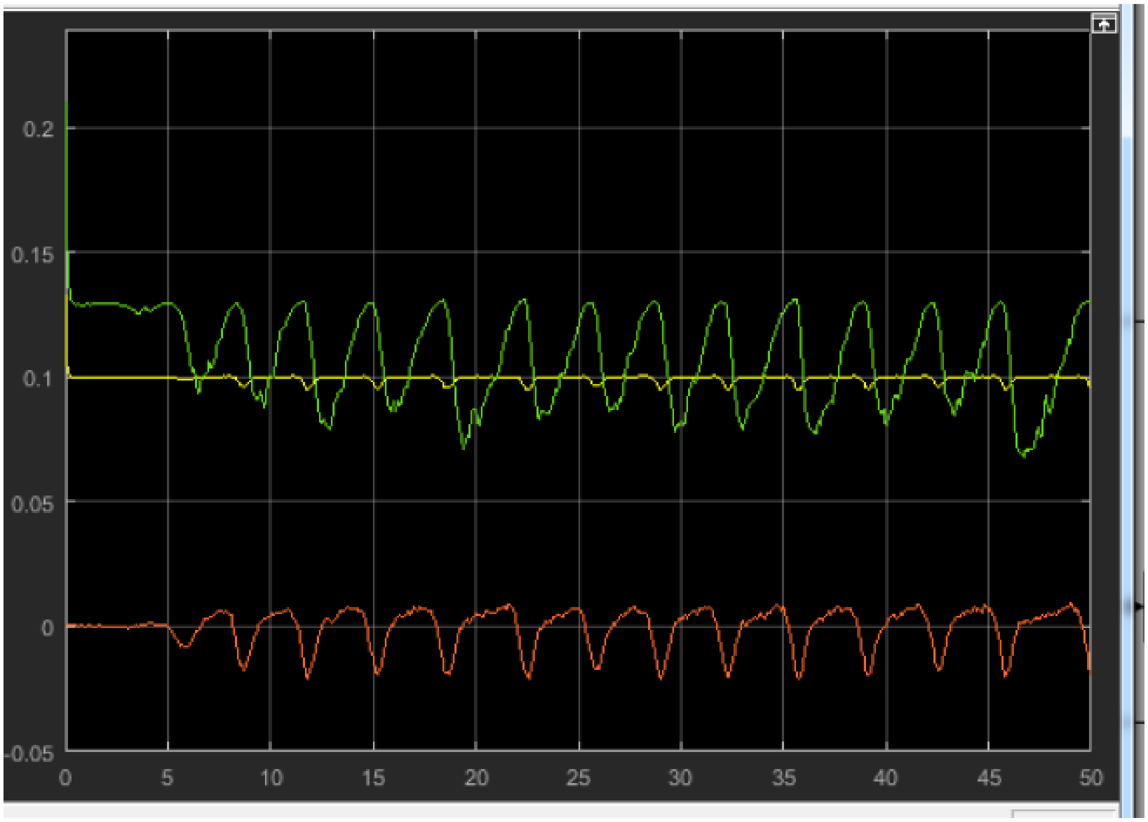
For error and covariance of state 1 and state 2:



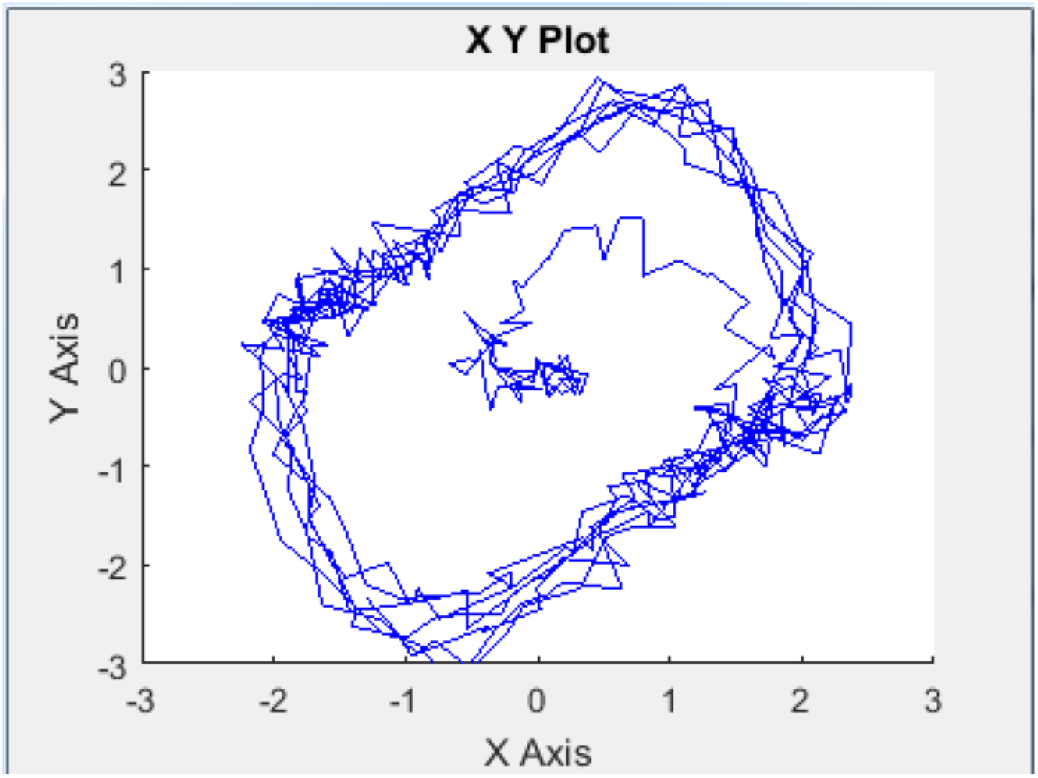


The values of Kalman gain k and error covariance, P:

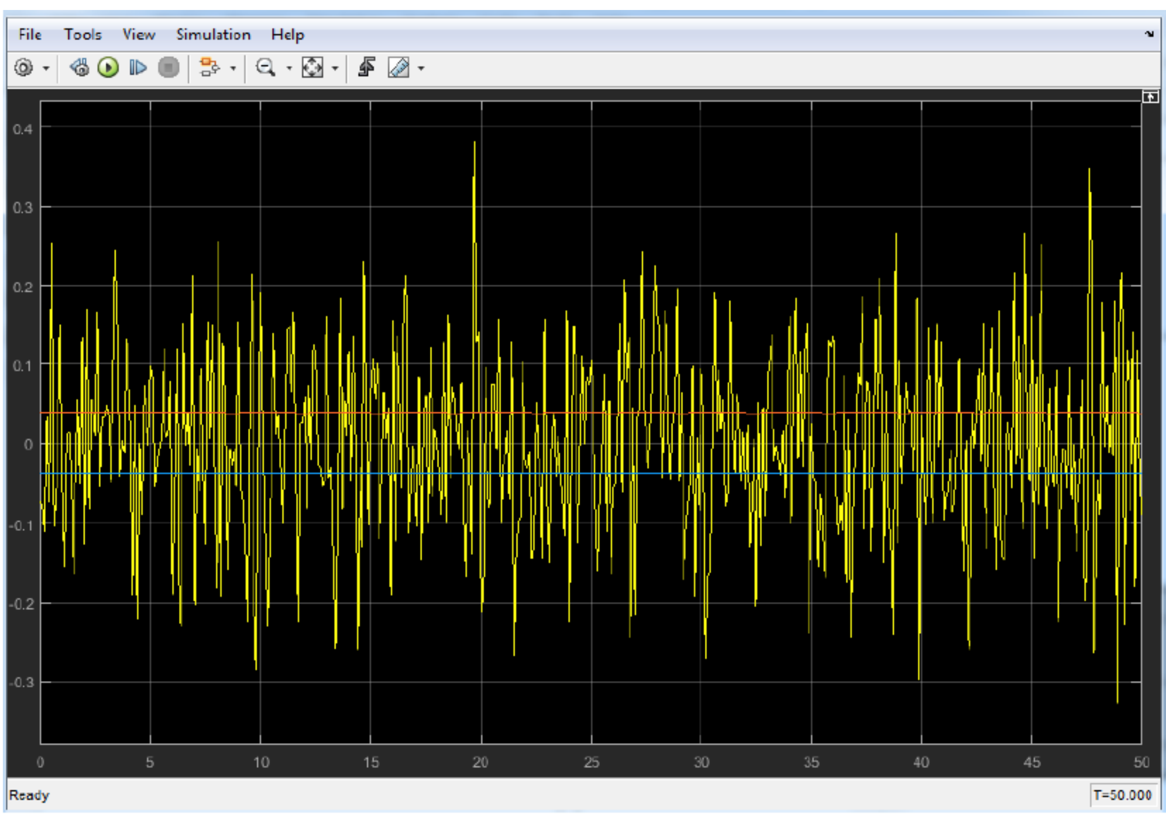


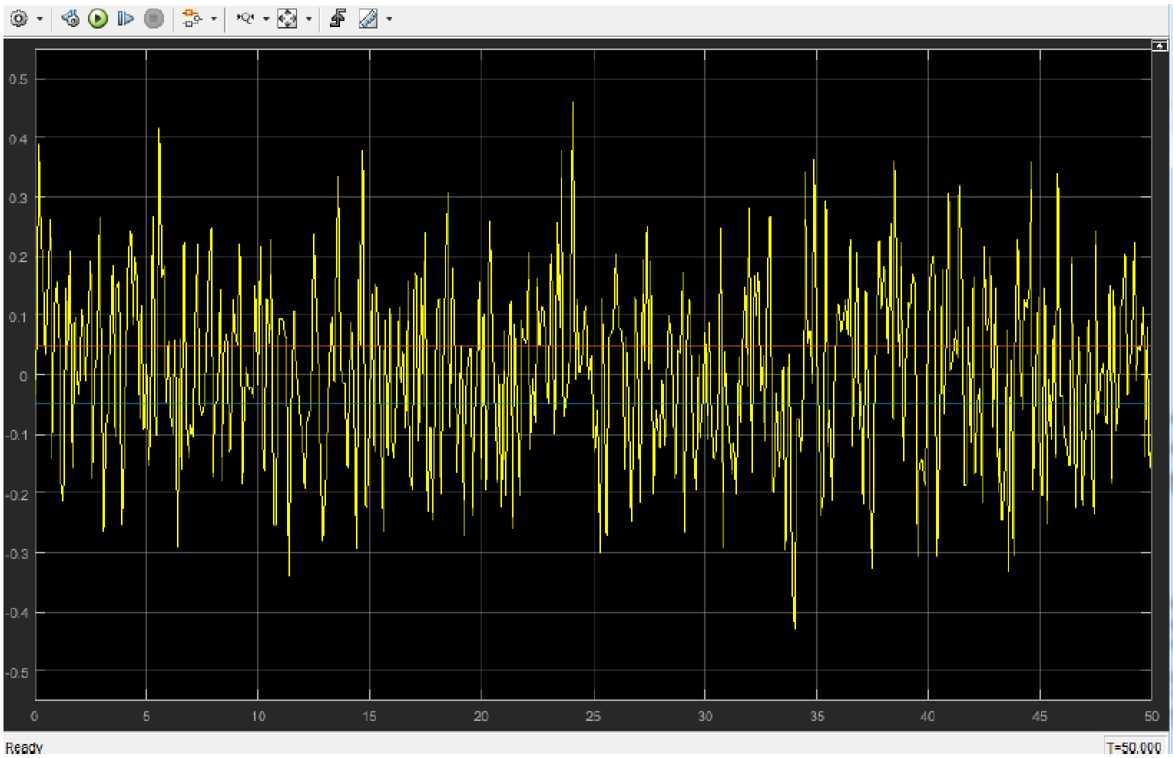


When R = diag([0.0015 0.0025])
The phase plots for given condition looks like:

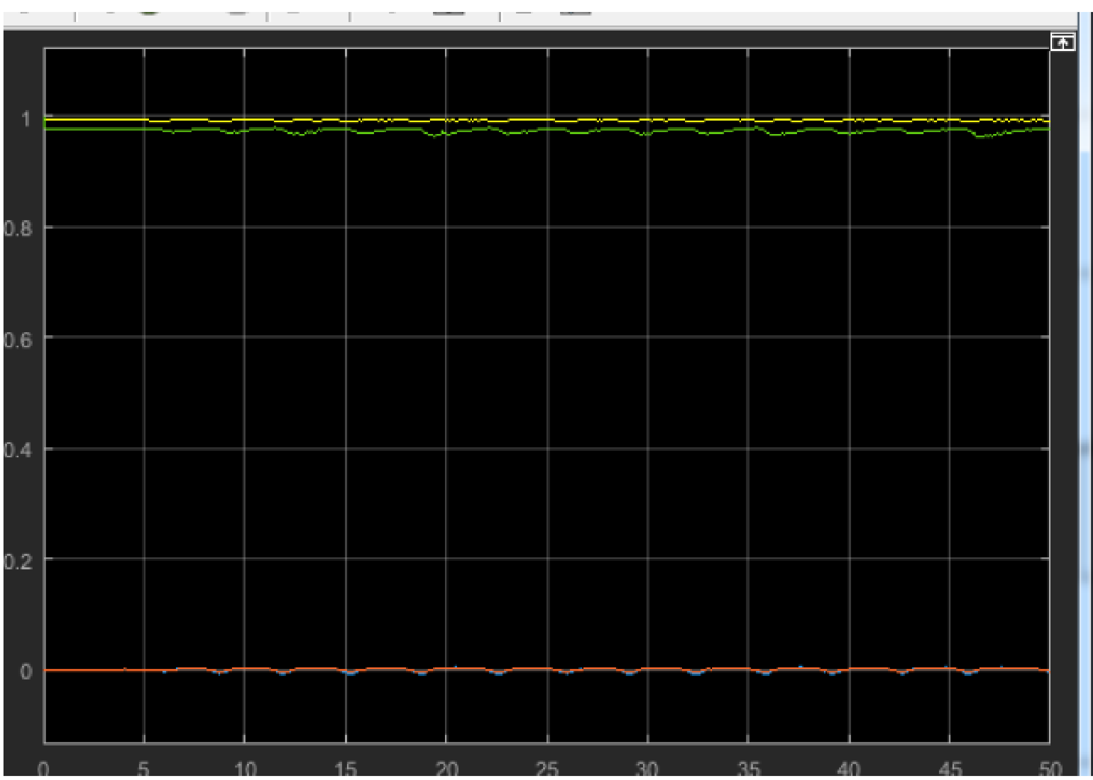


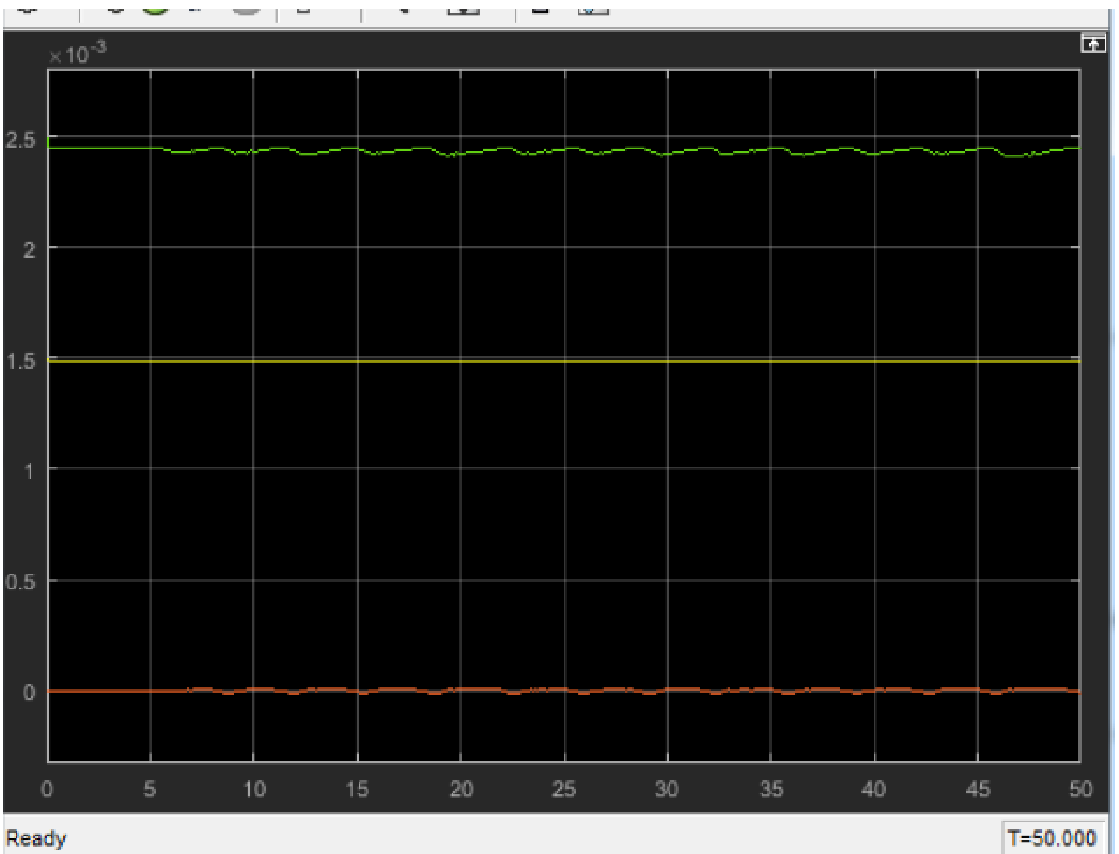
For error and covariance of state 1 and state 2:





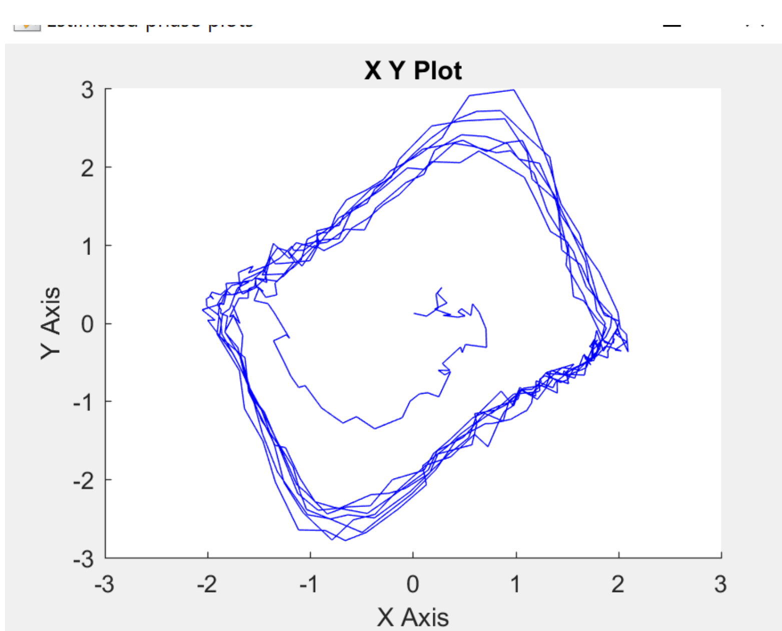
The values of Kalman gain k and error covariance, P:



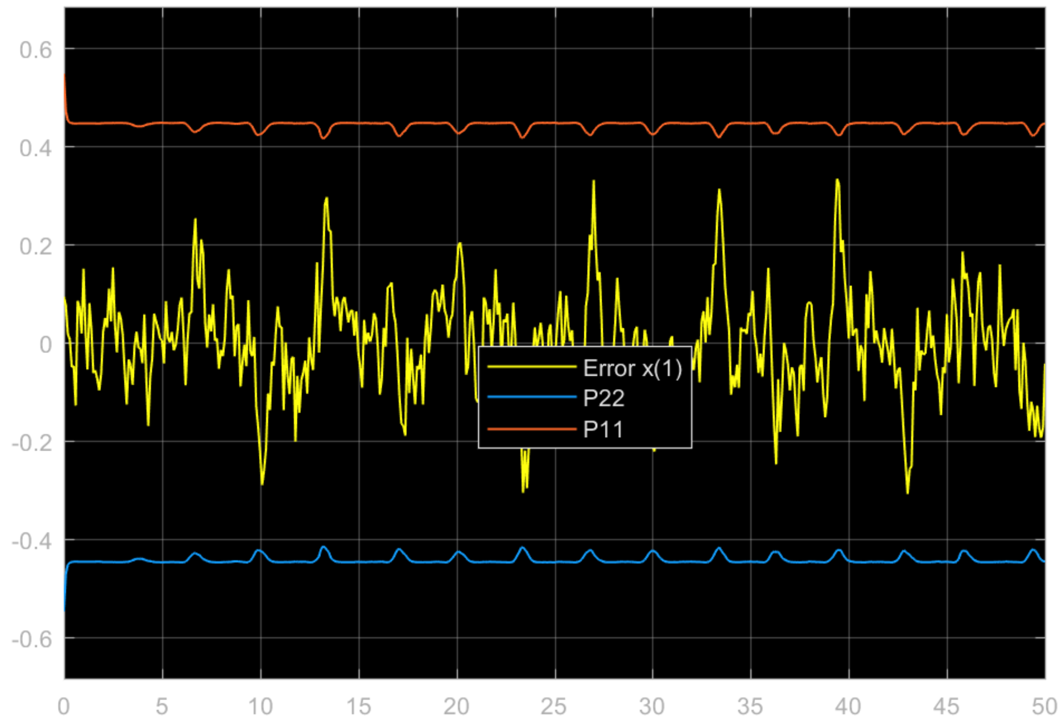


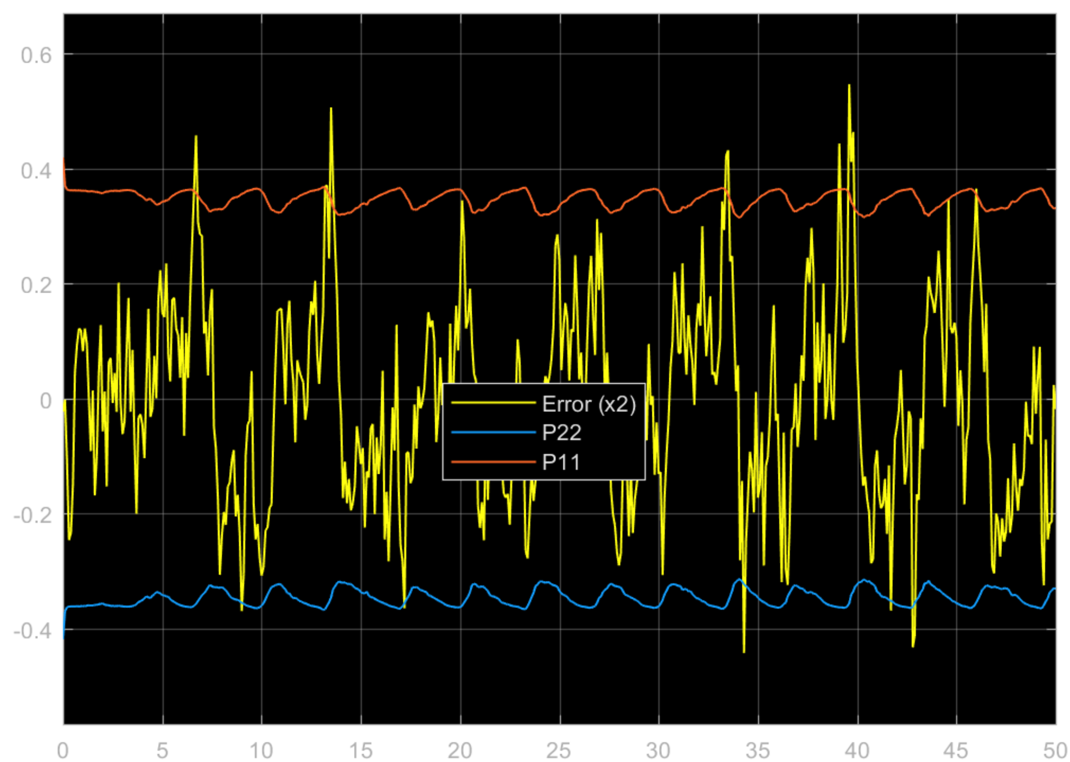
If the value of Q is fixed and with a high value of R, error set to the covariance limit is maximum.

d) When Q=diag([2 2]) and R =diag([0.4 0.2])
   The phase plots for given condition looks like:

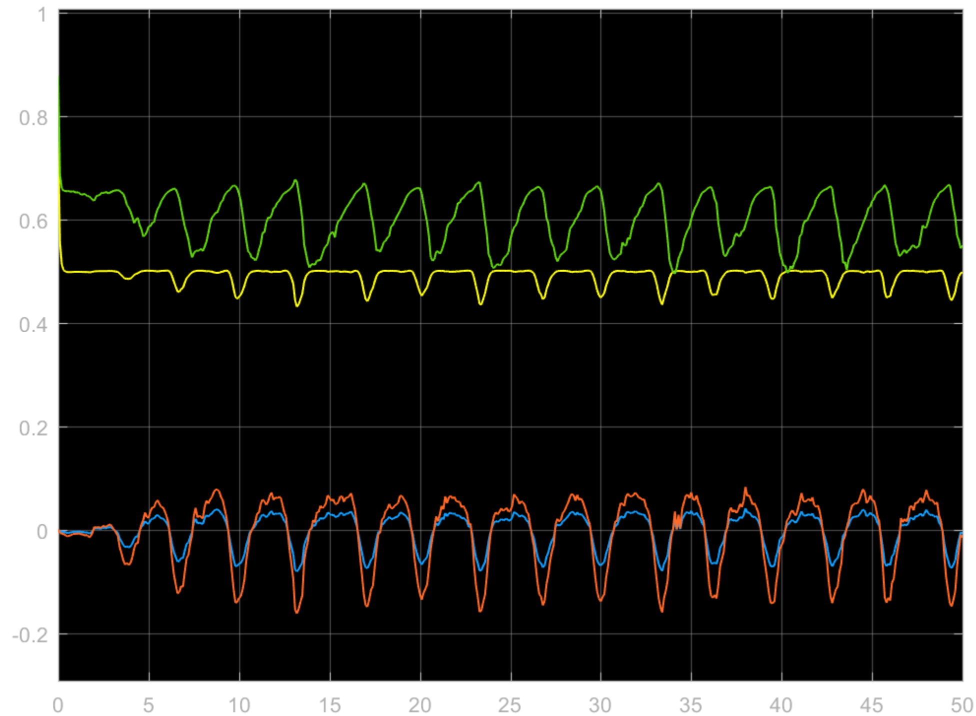


For error and covariance of state 1 and state 2:





The values of Kalman gain k and error covariance, P:


1
0.8
0.6
0.4
0.2
0
-0.2
0
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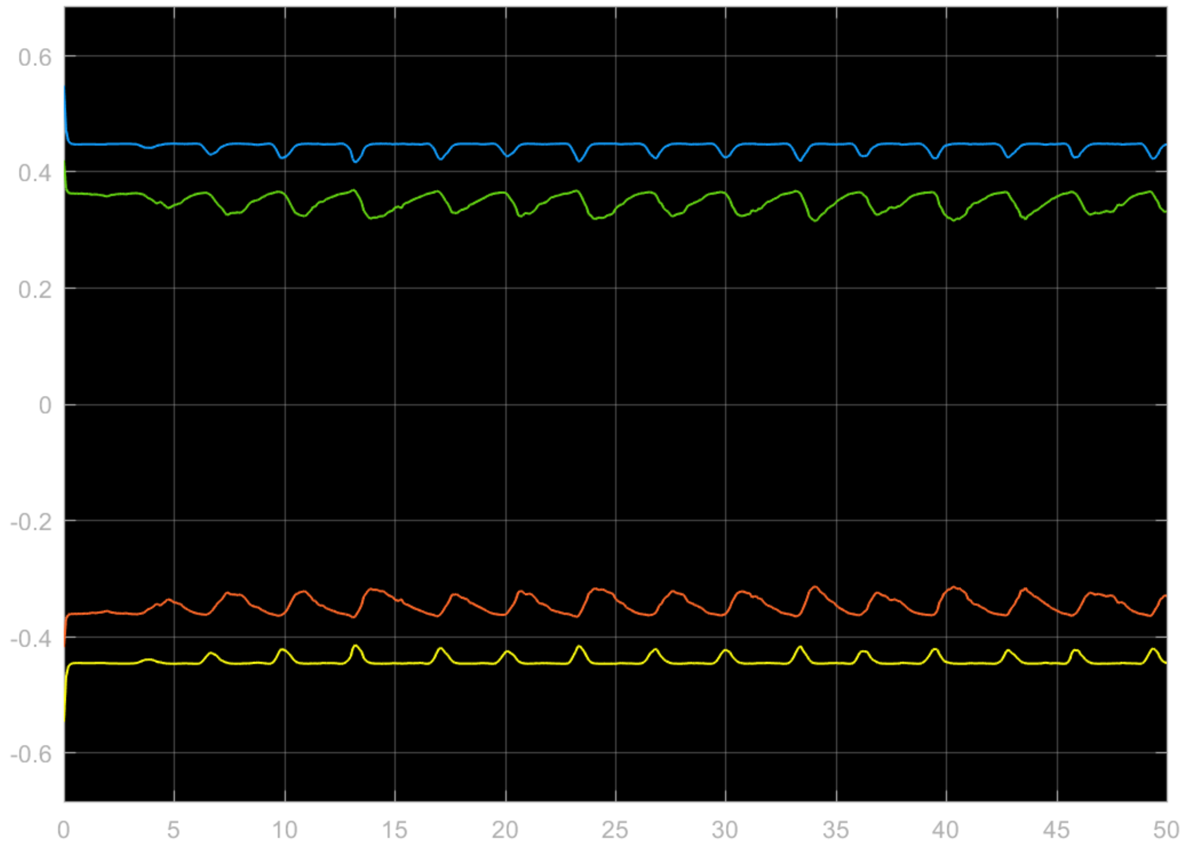
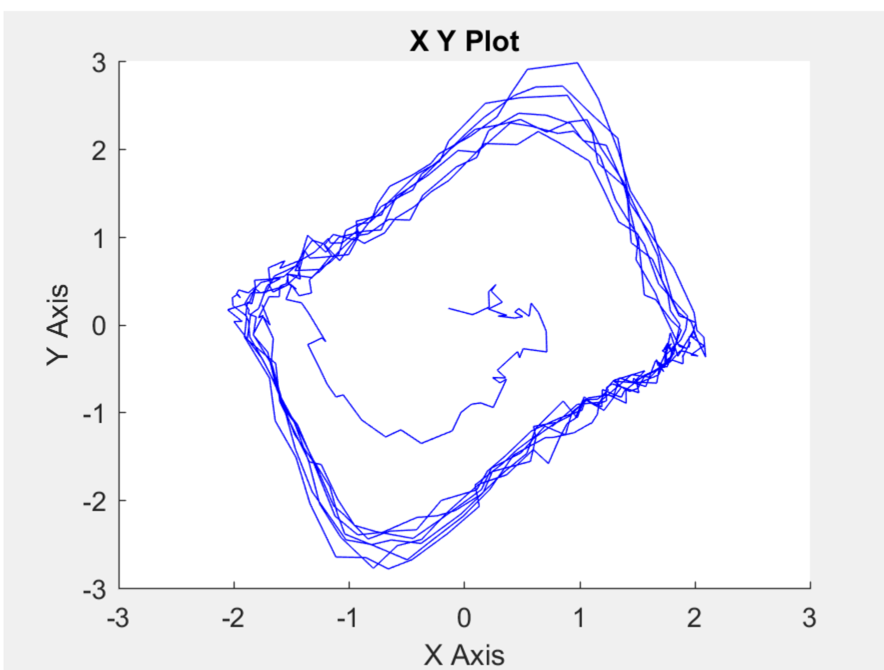
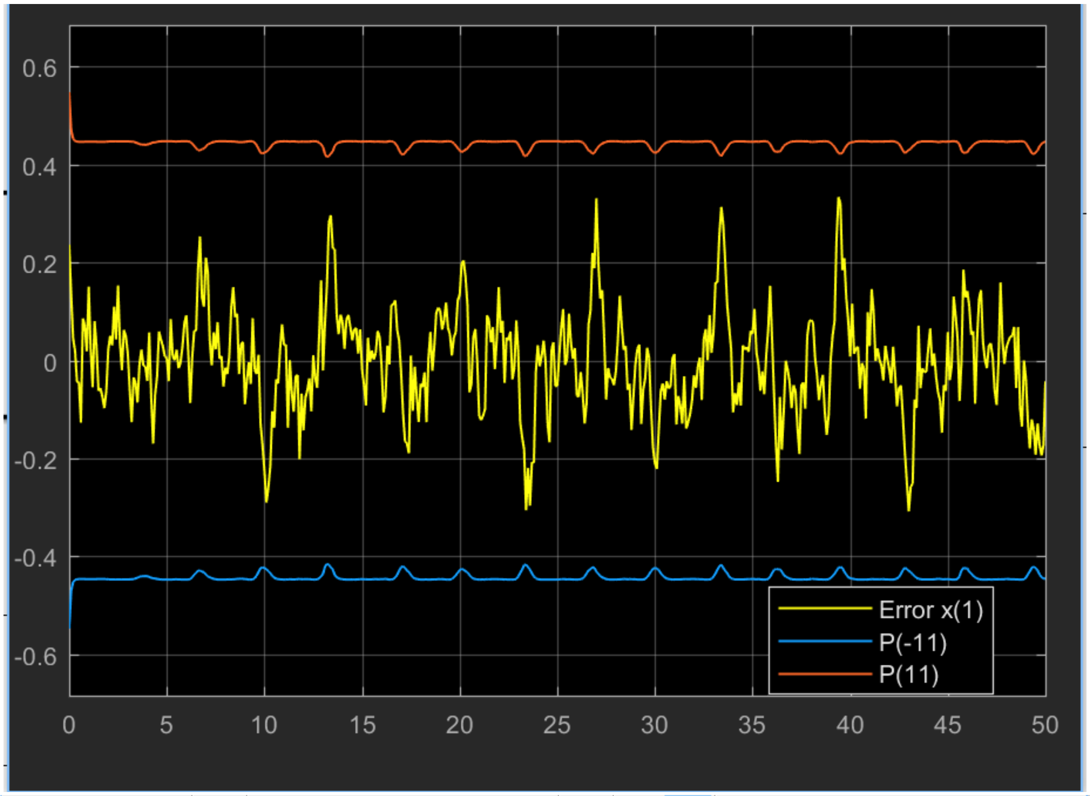
50

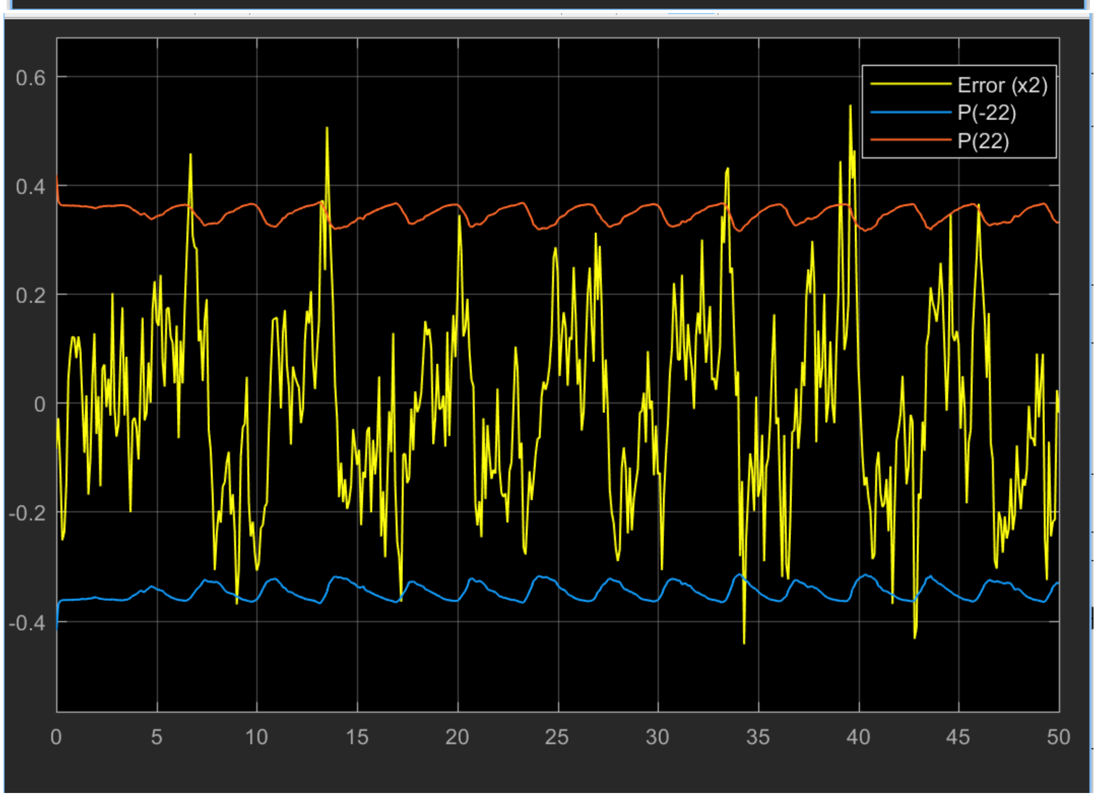


e) When the initial conditions of the predicted states is changed to [-0.5,0.5], The phase plots for given condition looks like:

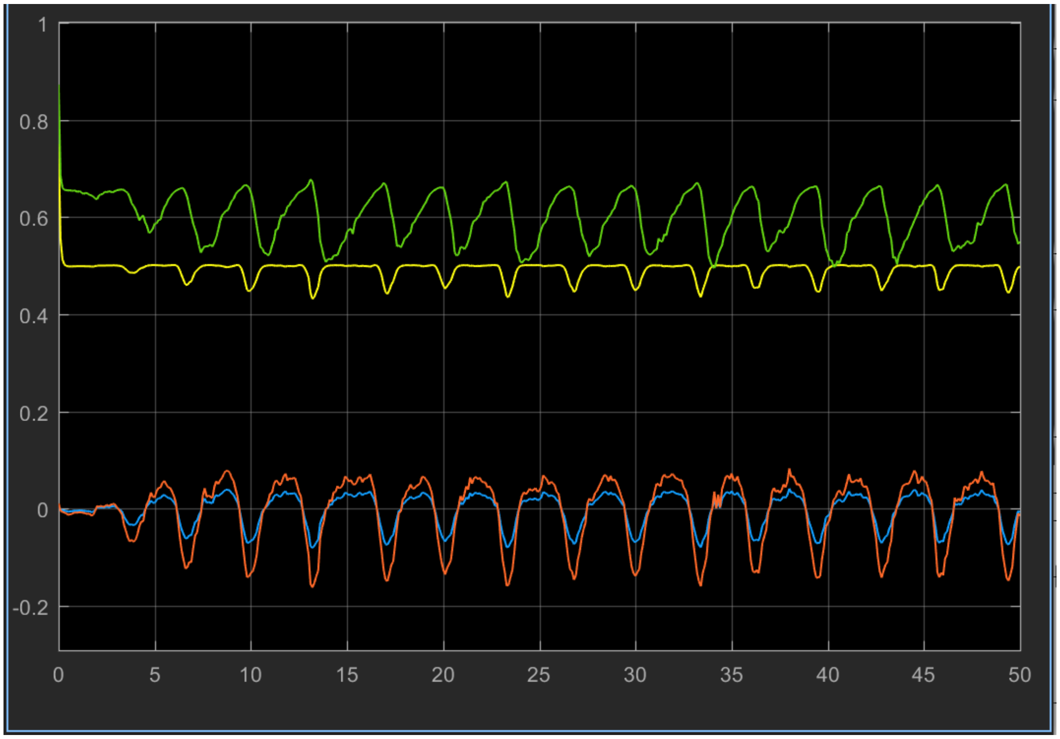


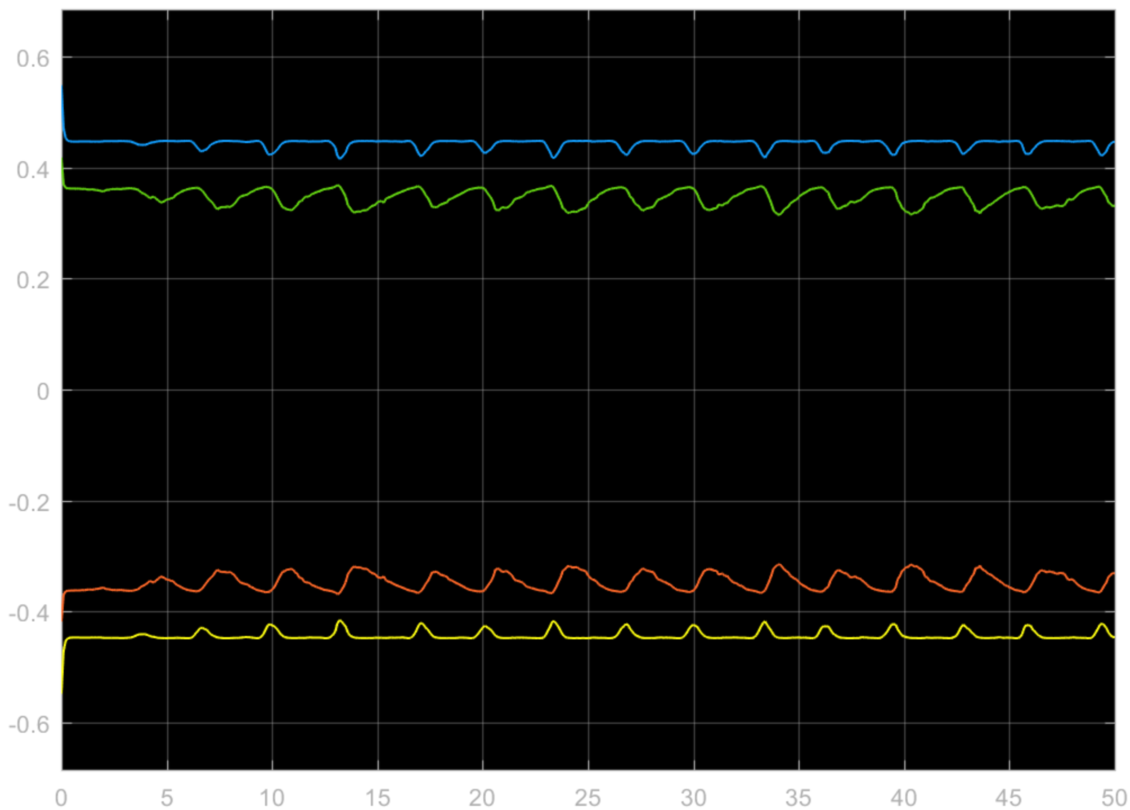
For error and covariance of state 1 and state 2:





The values of Kalman gain k and error covariance, P:





It can be seen from the previous part that the response for both the systems is similar although the initial conditions are changed for this part.

Therefore, there is no necessity to retune the filter if the initial conditions change for this dynamic system.

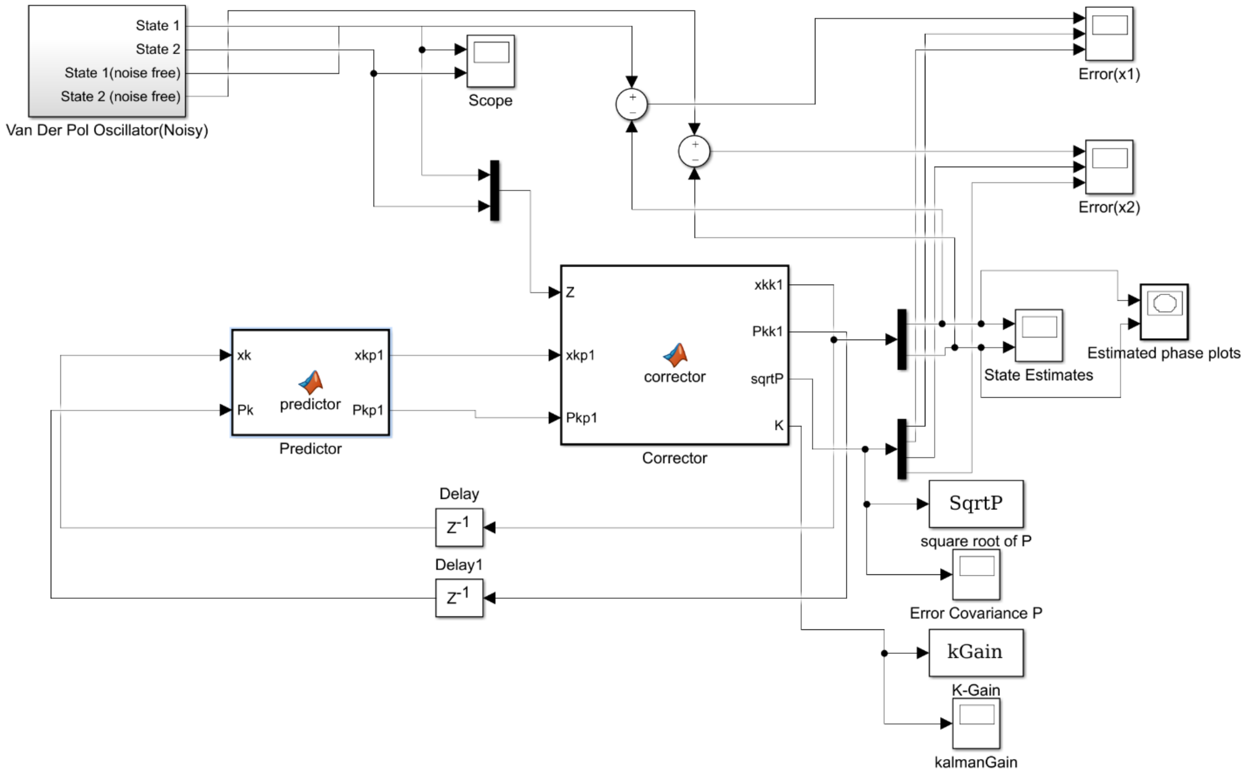
f) Predictor block MATLAB script

```
function [xkp1, Pkp1] = predictor(xk, Pk)

xkp1=zeros(2,1);
Pkp1=zeros(2);

x1=xk(1);
x2=xk(2);
a =[0 1; -2*x1*x2-1 1-x1*x1];

Q = diag([2 2]);
%Pk=eye(2);
T=0.1;
Ad=expm(a*T);

F=[-a Q;zeros(2,2) a'];
G=expm(F*T);
GLr=G(3:4,3:4);
Gur=G(1:2,3:4);
Qd=GLr'*Gur;

xkp1=Ad*xk;
Pkp1=Ad*Pk*Ad'+Qd;

end
```

Corrector block MATLAB script

```
function [xkk1, Pkk1,sqrtP,K] = corrector(Z,xkp1,Pkp1)

xkk1=zeros(2,1);
Pkk1=zeros(2);
sqrtP=zeros(4,1);


R=diag([0.4, 0.2]);

H=eye(2);
dh=eye(2);

K=Pkp1*dh'*inv(dh*Pkp1*(dh)'+R);
Pkk1=Pkp1- K*(dh*Pkp1*(dh)'+R)*K';
xkk1=xkp1+K*(Z-H*xkp1);

P22=Pkk1(2,2)
sqrtP(4,1)=sqrt(P22);
sqrtP(3,1)=-sqrt(P22);
P11=Pkk1(1,1)
sqrtP(2,1)=sqrt(P11);
sqrtP(1,1)=-sqrt(P11);
```

```
end
```



State 1
State 2
State 1(noise free)
State 2 (noise free)
Van Der Pol Oscillator(Noisy)
Scope
Error(x1)
Error(x2)
Z
xkk1
Pkk1
xkp1
corrector
sqrtP
Pkp1
K
Corrector
xk
predictor
xkp1
Pk
Pkp1
Predictor
State Estimates
Estimated phase plots
Delay
Delay1
SqrtP
square root of P
Error Covariance P
kGain
K-Gain
kalmanGain