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Robot Control Assignment 4 Report

1)

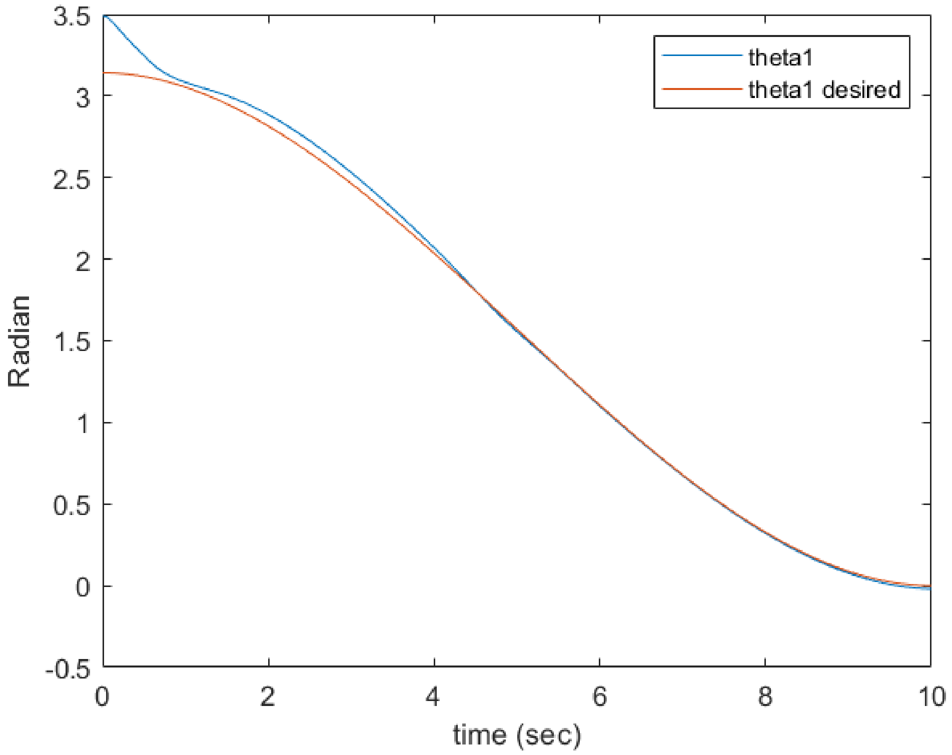
```
Y = [ddq1, ...
cos(q2)*(2*ddq1 + ddq2) - 2*sin(q2)*dq1*dq2 - sin(q2)*dq2^2, ...
ddq2, ...
-sin(q1)*g, ...
-sin(q1 + q2)*g; ...
0, ...
sin(q2)*dq1^2 + cos(q2)*ddq1, ...
ddq1 + ddq2, ...
0, ...
-sin(q1+q2)*g];

% Corrected alpha vector
alpha = [m1*r1^2 + m2*l1^2 + m2*r2^2 + I1 + I2;
         m2*l1*r2;
         m2*r2^2 + I2;
         m1*r1 + m2*l1;
         m2*r2];

% Compute the product Y * alpha
Y_alpha = Y * alpha;

a = I1 + I2 + m1*r1^2 + m2*(l1^2 + r2^2);
b = m2*l1*r2;
d = I2 + m2*r2^2;

% Mmat, Cmat, and Gmat taken from the assignments
Mmat = [a+2*b*cos(q2), d+b*cos(q2); d+b*cos(q2), d];
Cmat = [-b*sin(q2)*dq2, -b*sin(q2)*(dq1+dq2); b*sin(q2)*dq1,0];
Gmat = [-m1*g*r1*sin(q1)-m2*g*(l1*sin(q1)+r2*sin(q1+q2)); -m2*g*r2*sin(q1+q2)];

% Compute tau using the manipulator equation
tau = Mmat * [ddq1; ddq2] + Cmat * [dq1; dq2] + Gmat;

% Compare the terms in the product Y * alpha with the manipulator form equations
result1 = simplify(Y_alpha(1) - tau(1));
result2 = simplify(Y_alpha(2) - tau(2));

% If both results are zero, then the Y matrix and alpha vector match the manipulator form equations
if result1 == 0 && result2 == 0
    disp('The provided Y matrix and alpha vector match the manipulator form equations.')
else
    disp('The provided Y matrix and alpha vector do not match the manipulator form equations.')
end
```

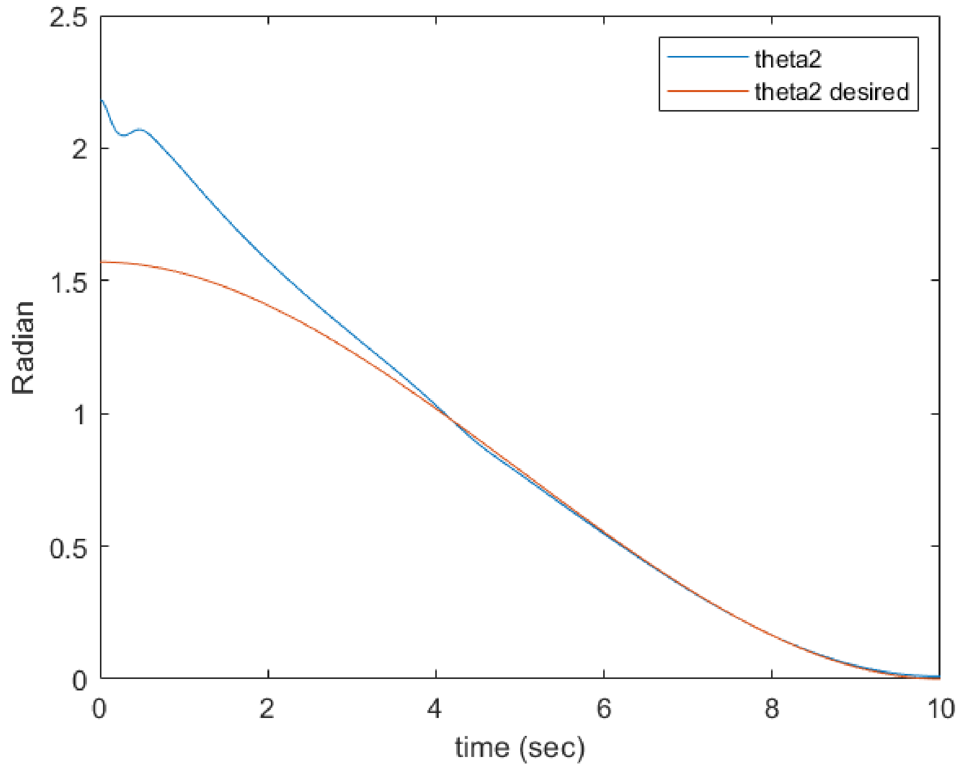
```
The provided Y matrix and alpha vector match the manipulator form
equations.
```

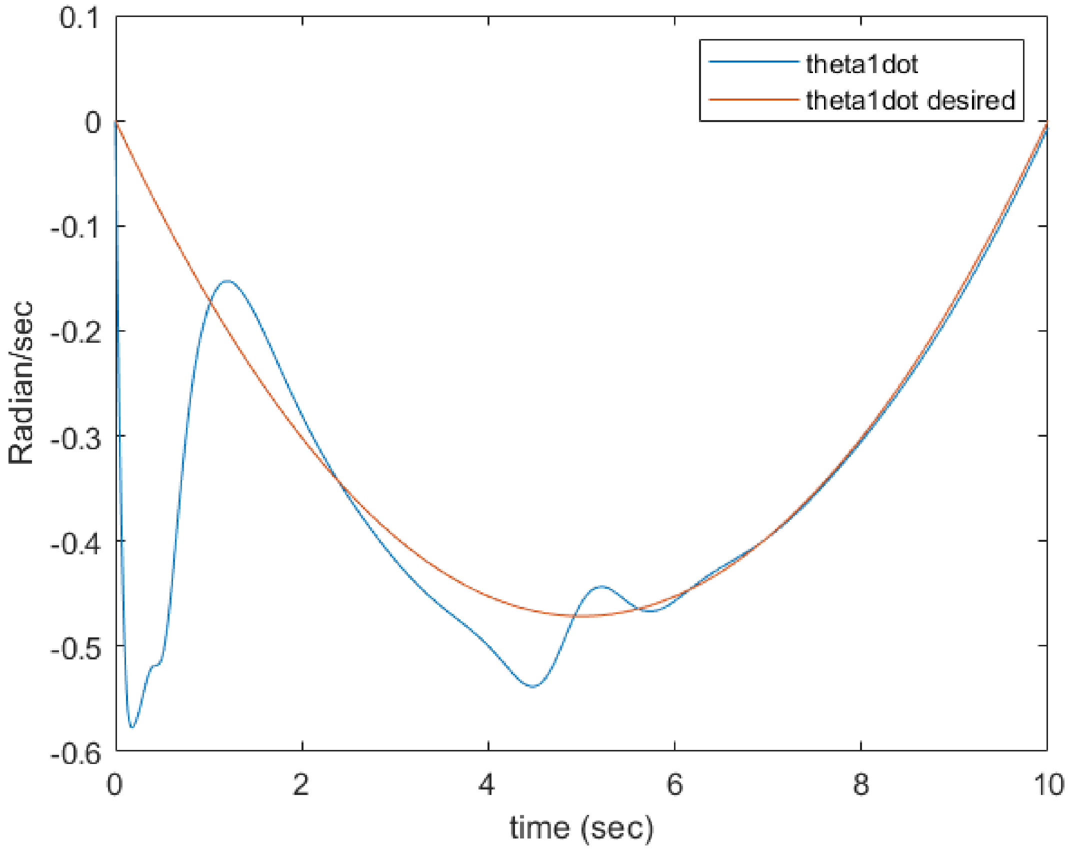

```
The provided Y matrix and alpha vector match the manipulator form
equations.
```

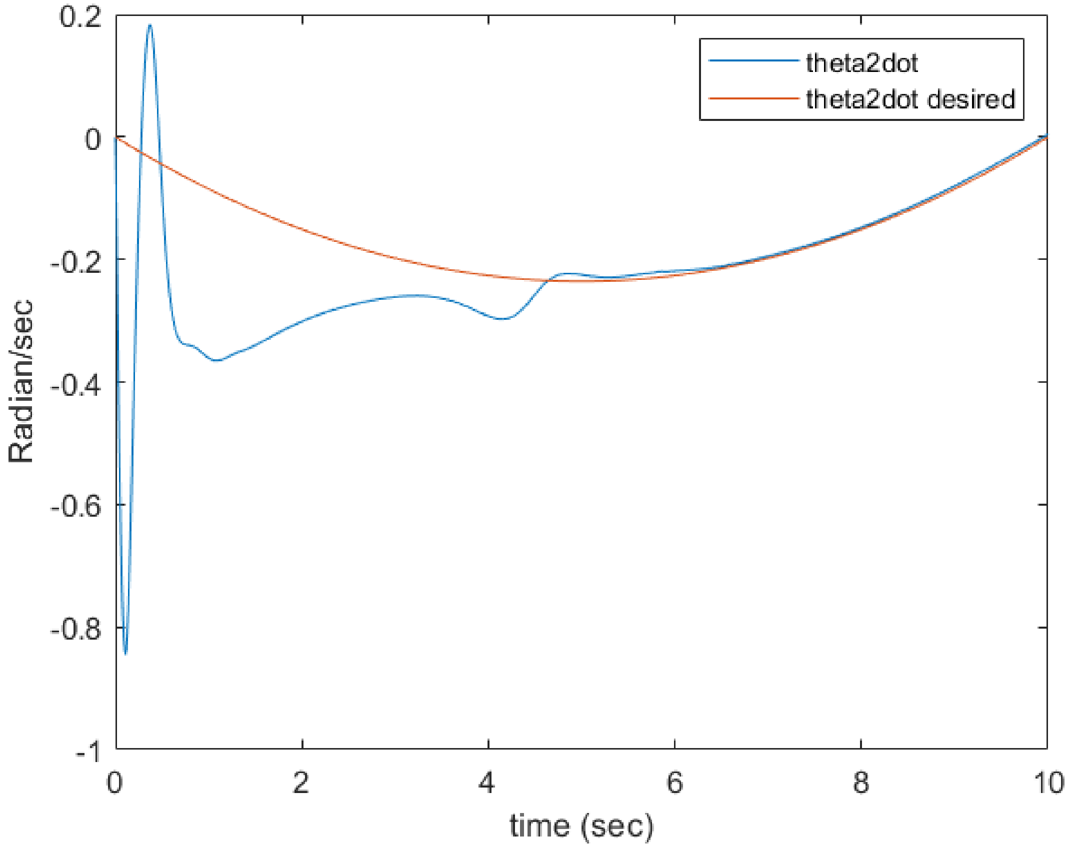
```
A = 4×4
     0     0     1     0
     0     0     0     1
     0     0     0     0
     0     0     0     0

B = 4×2
     0     0
     0     0
     1     0
     0     1

eigenvalues = 1×4
    -2    -2    -3    -3

Kp and Kd values

k = 2×4
    6.0000         0    5.0000         0
         0    6.0000         0    5.0000

Acl = 4×4
         0         0    1.0000         0
         0         0         0    1.0000
   -6.0000         0   -5.0000         0
         0   -6.0000         0   -5.0000


Q = eye(4)*1.2


Gamma = eye(5)* 0.35
```

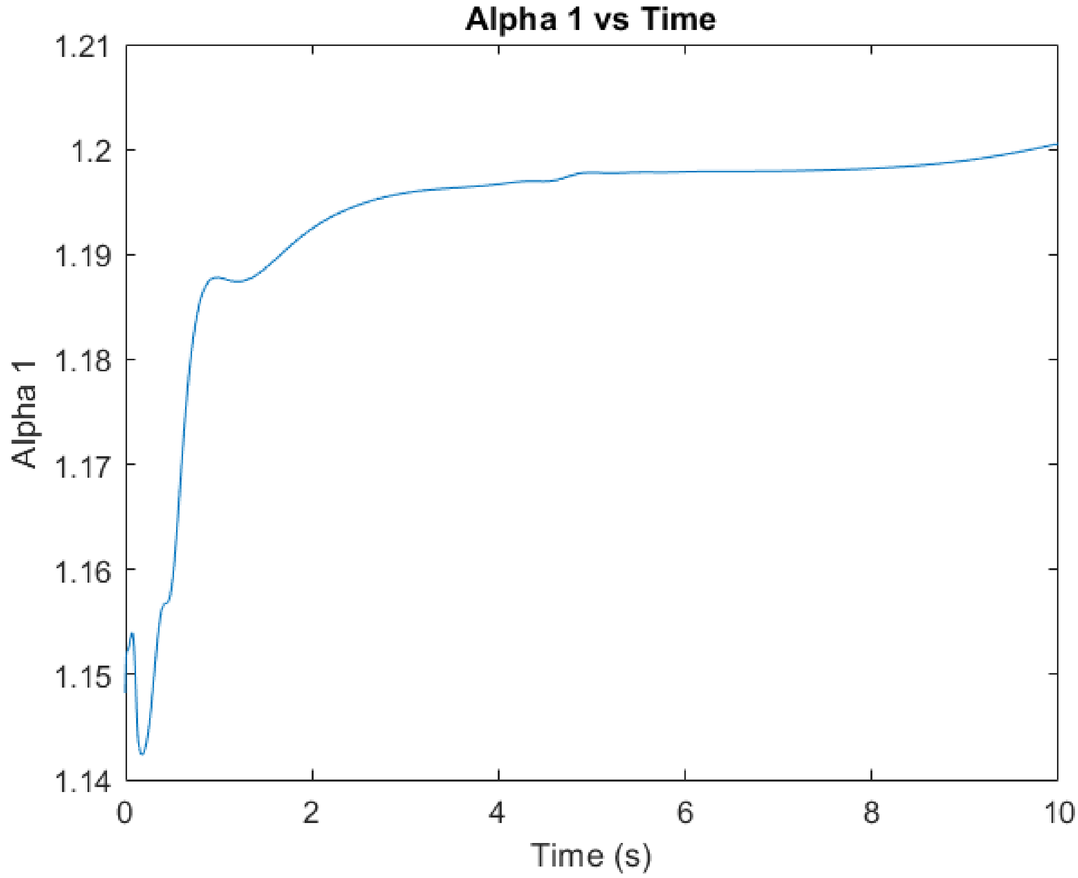
Plots with Adaptive inverse law

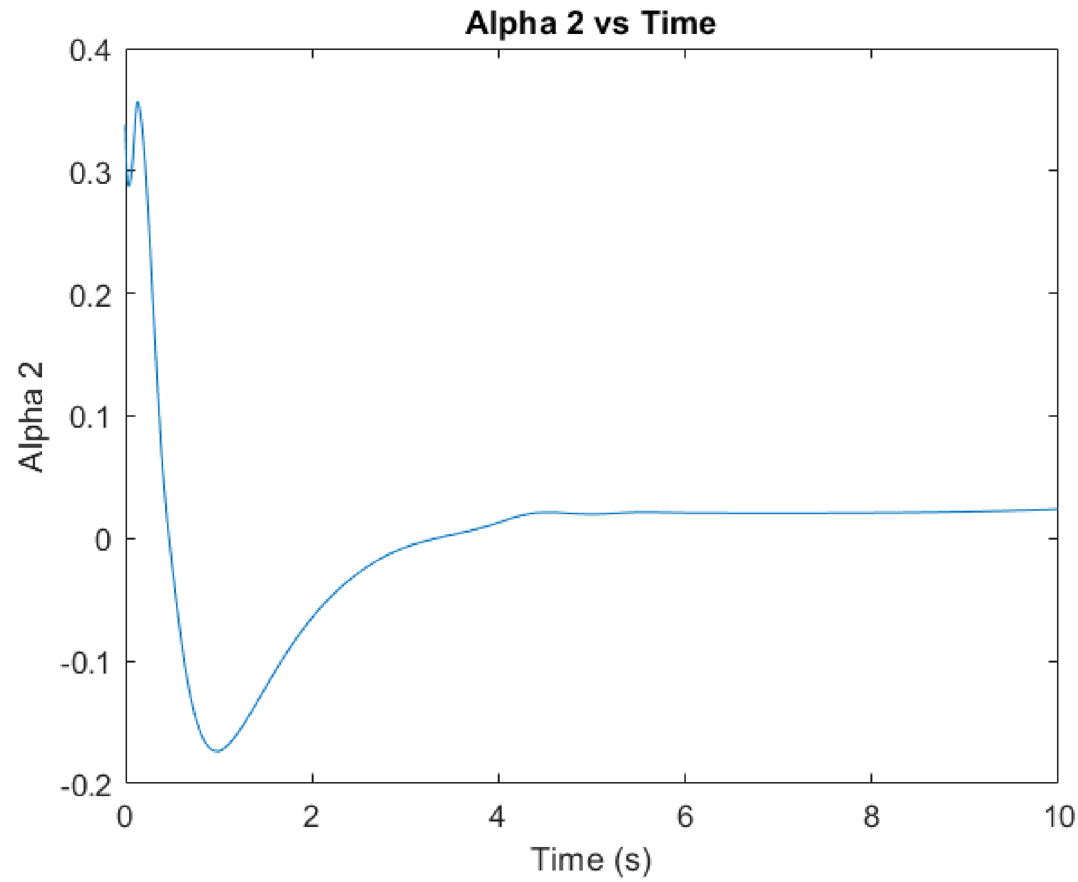


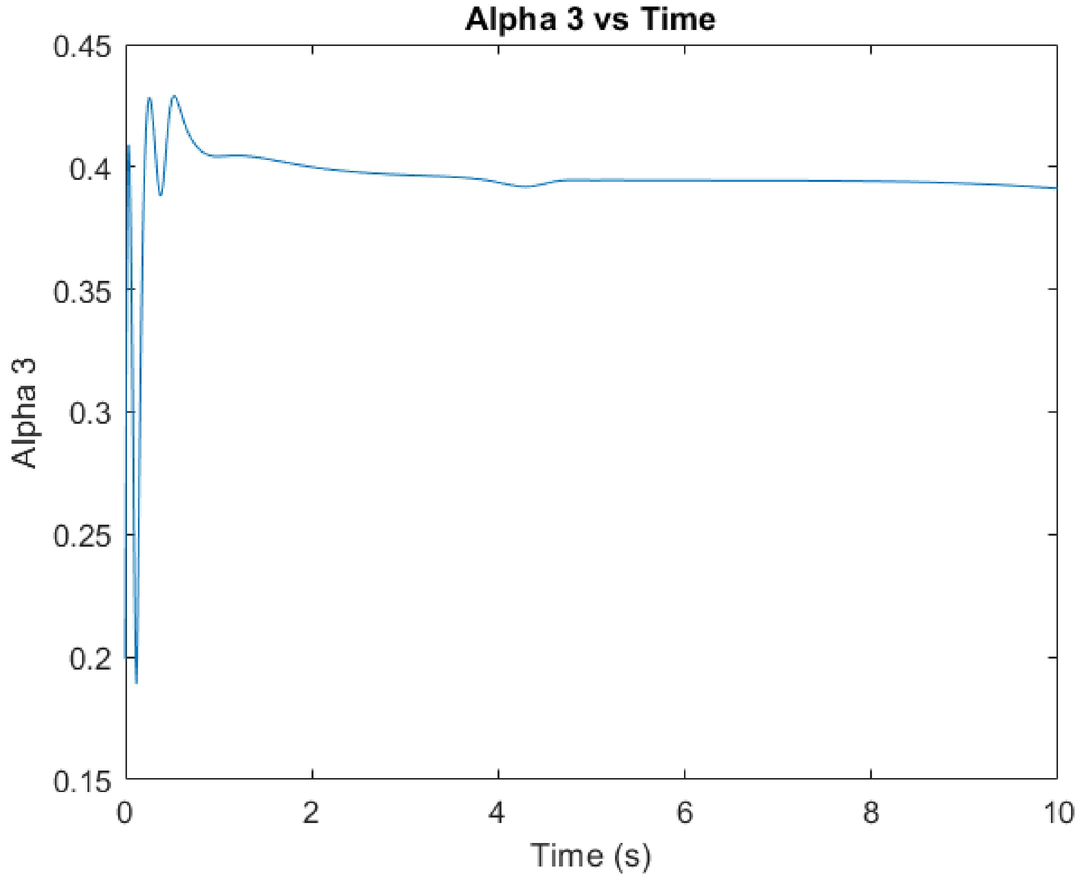


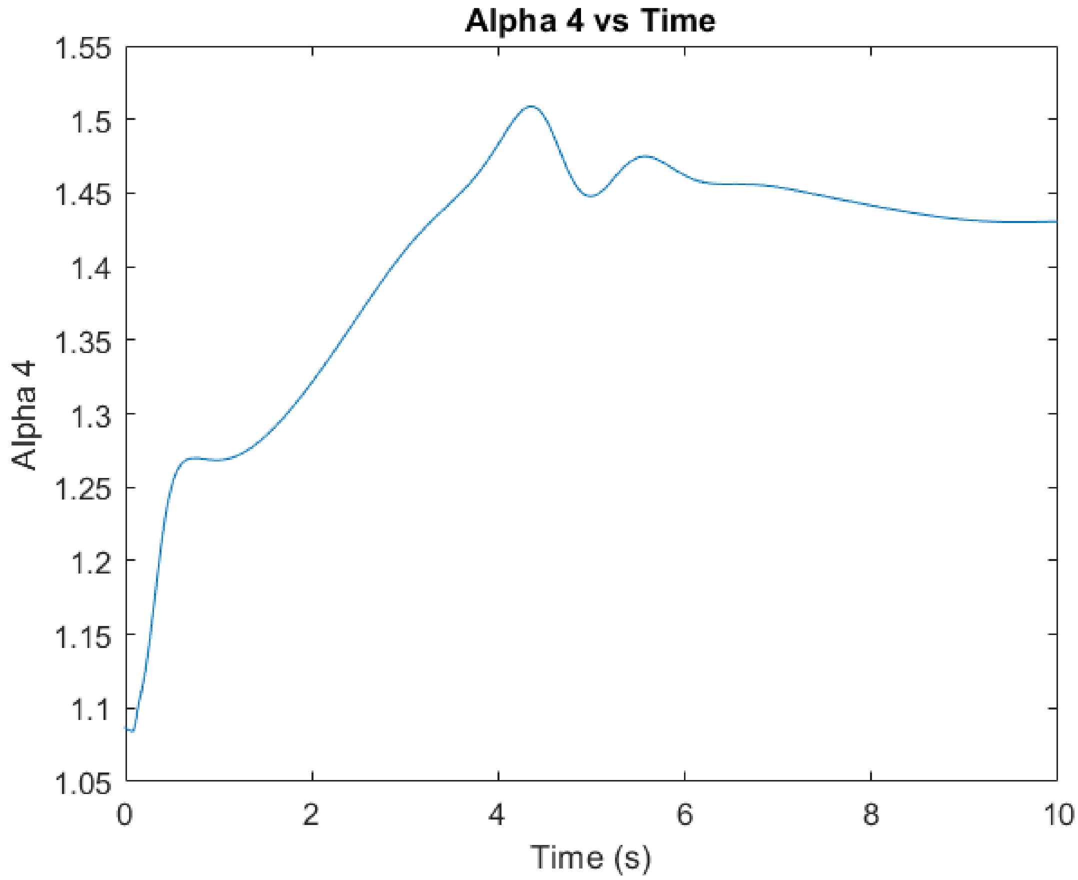

0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
Radian/sec
0
2
4
6
8
10
time (sec)
theta1dot
theta1dot desired

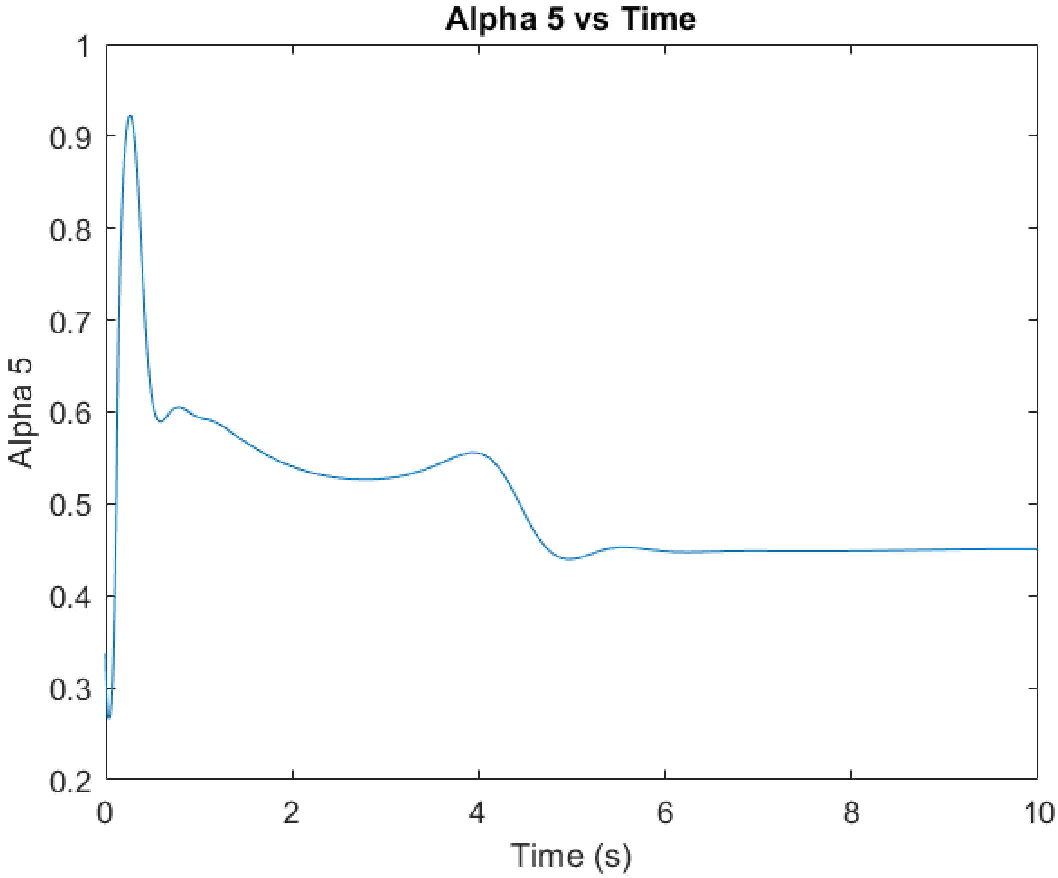

0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Radian/sec
0
2
4
6
8
10
time (sec)
theta2dot
theta2dot desired


Alpha 1 vs Time
Alpha 1
Time (s)
1.21
1.2
1.19
1.18
1.17
1.16
1.15
1.14
0
2
4
6
8
10

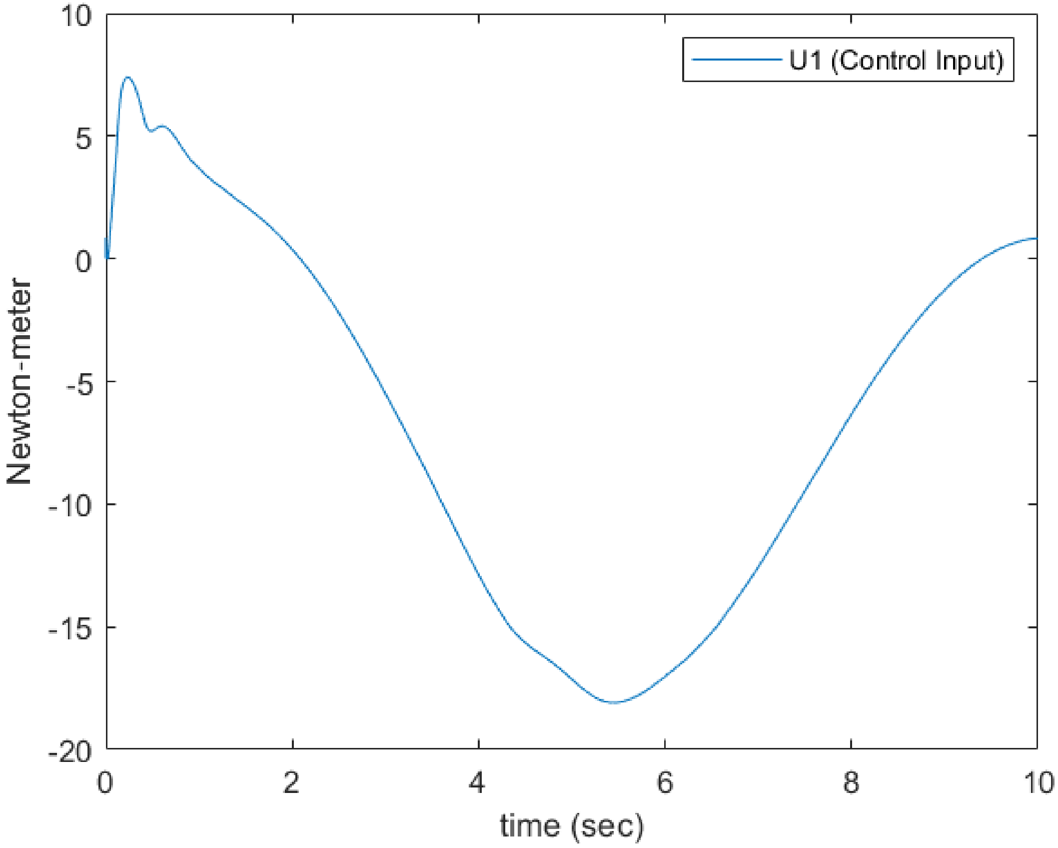

Alpha 2 vs Time
Alpha 2
Time (s)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0
2
4
6
8
10


Alpha 3 vs Time
0.45
0.4
0.35
0.3
0.25
0.2
0.15
Alpha 3
0
2
4
6
8
10
Time (s)

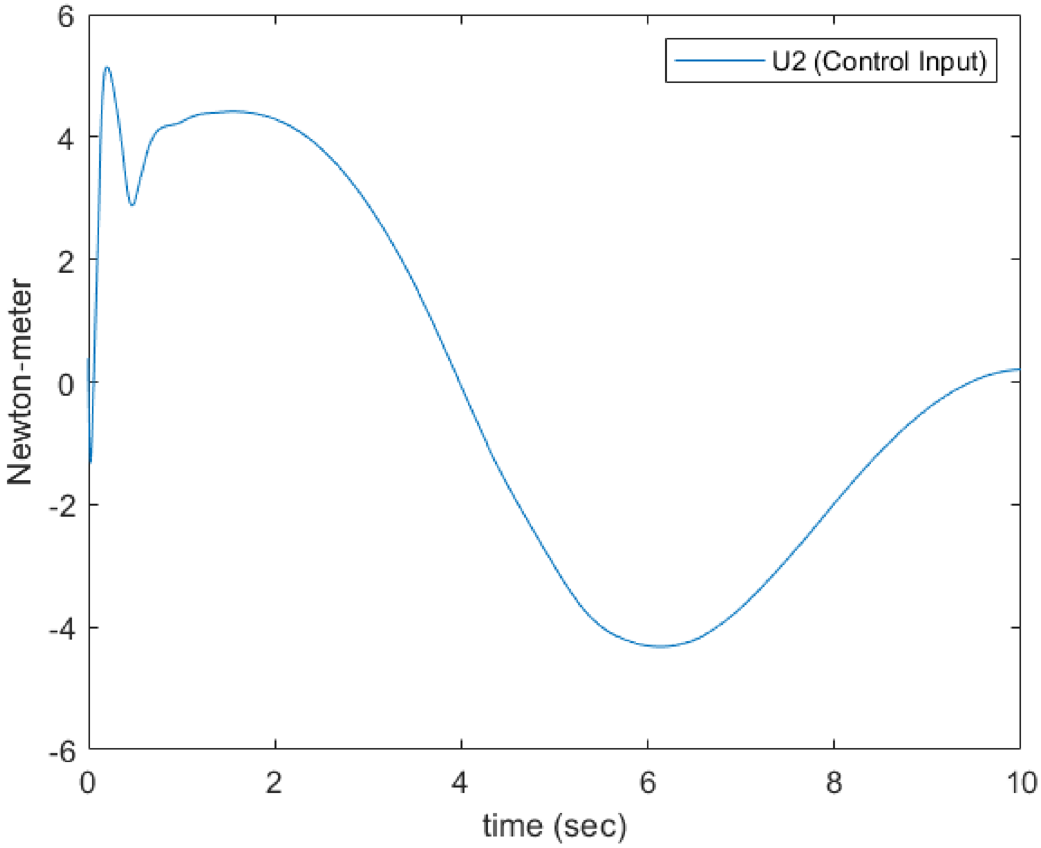

Alpha 4 vs Time
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
Alpha 4
0
2
4
6
8
10
Time (s)



Discussion : As seen from the plots above, when the adaptive inverse dynamics control law is used, there is less disturbances noticed in the plots and once the plots converge, they do not deviate much.

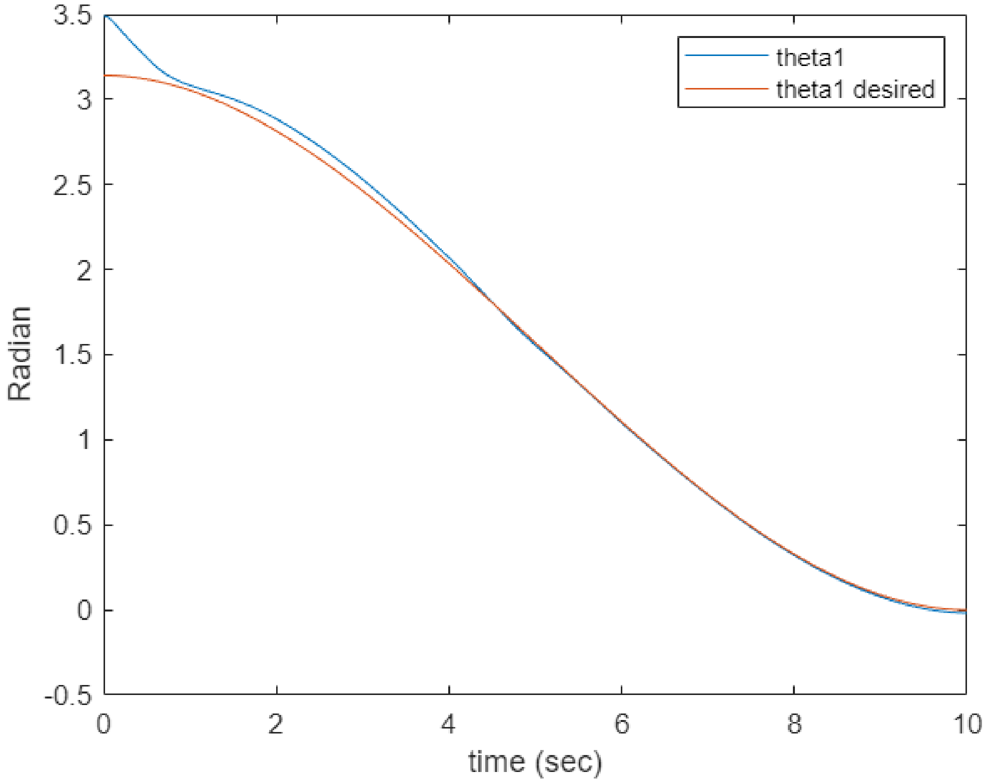


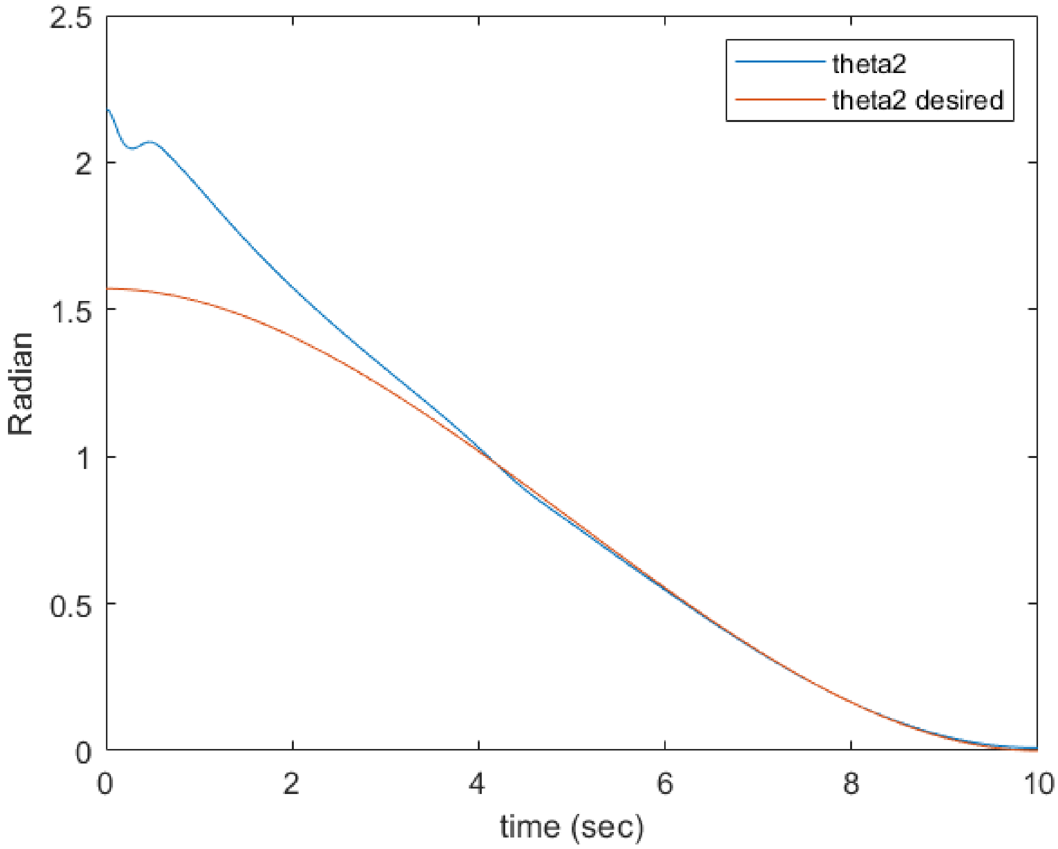
U1 (Control Input)
10
5
0
-5
-10
-15
-20
Newton-meter
0
2
4
6
8
10
time (sec)

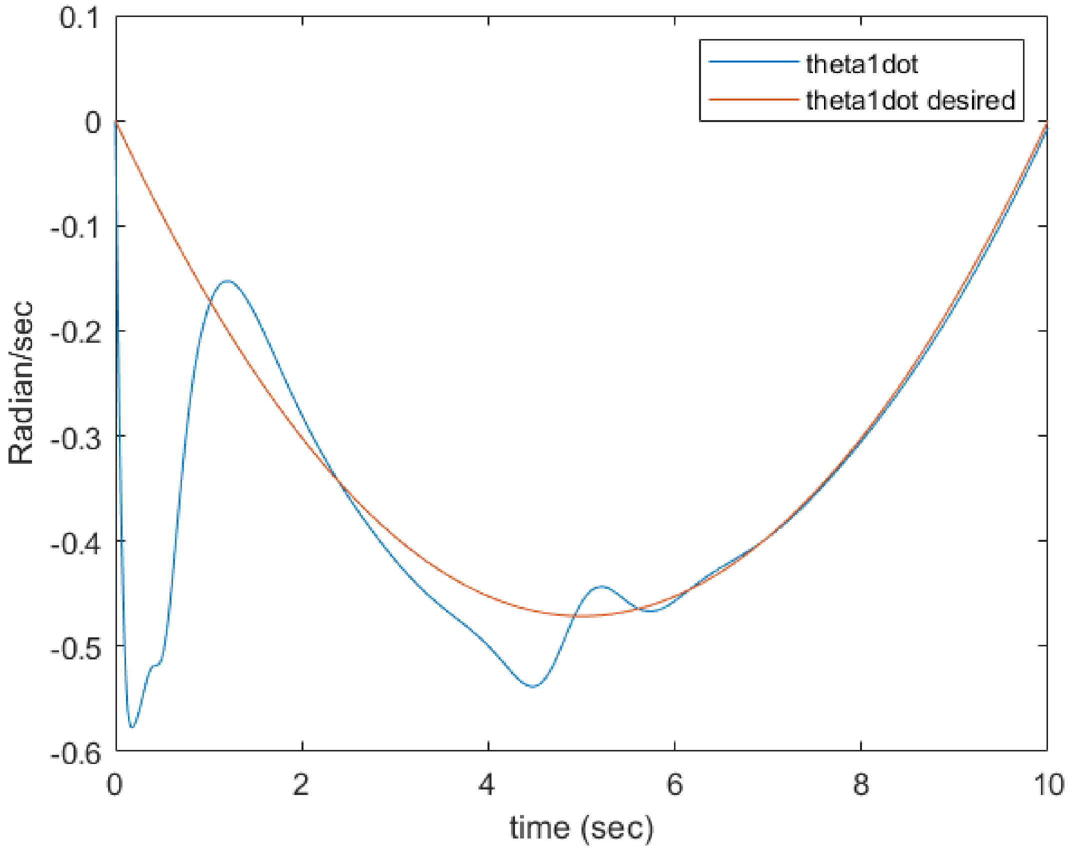


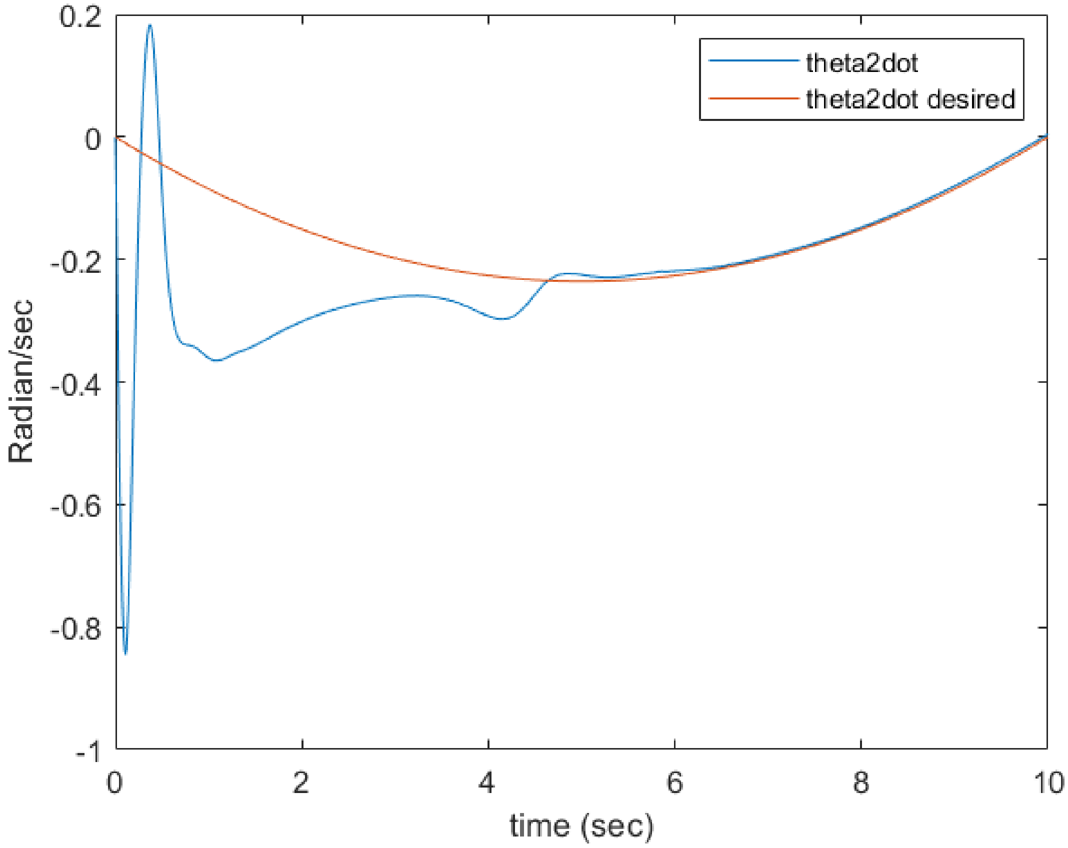
U2 (Control Input)
6
4
2
0
-2
-4
-6
Newton-meter
0
2
4
6
8
10
time (sec)

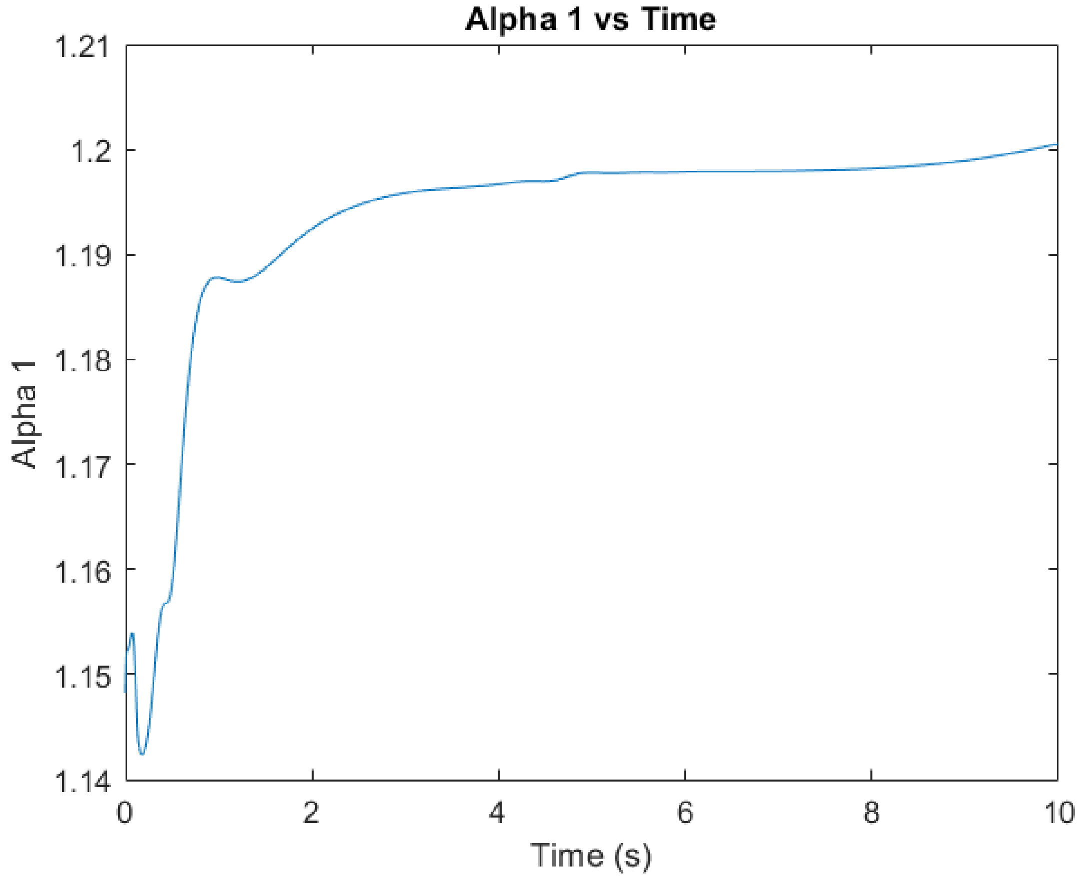
Plots without adaptive Inverse Law

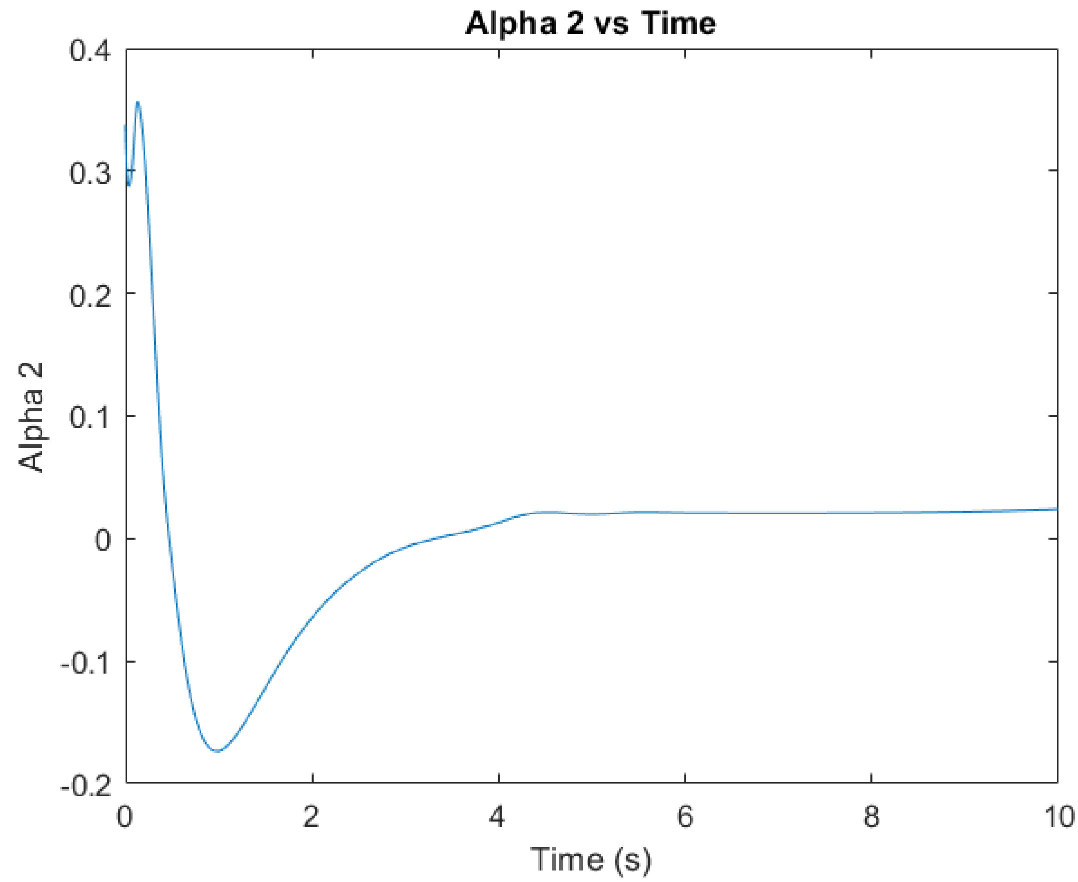


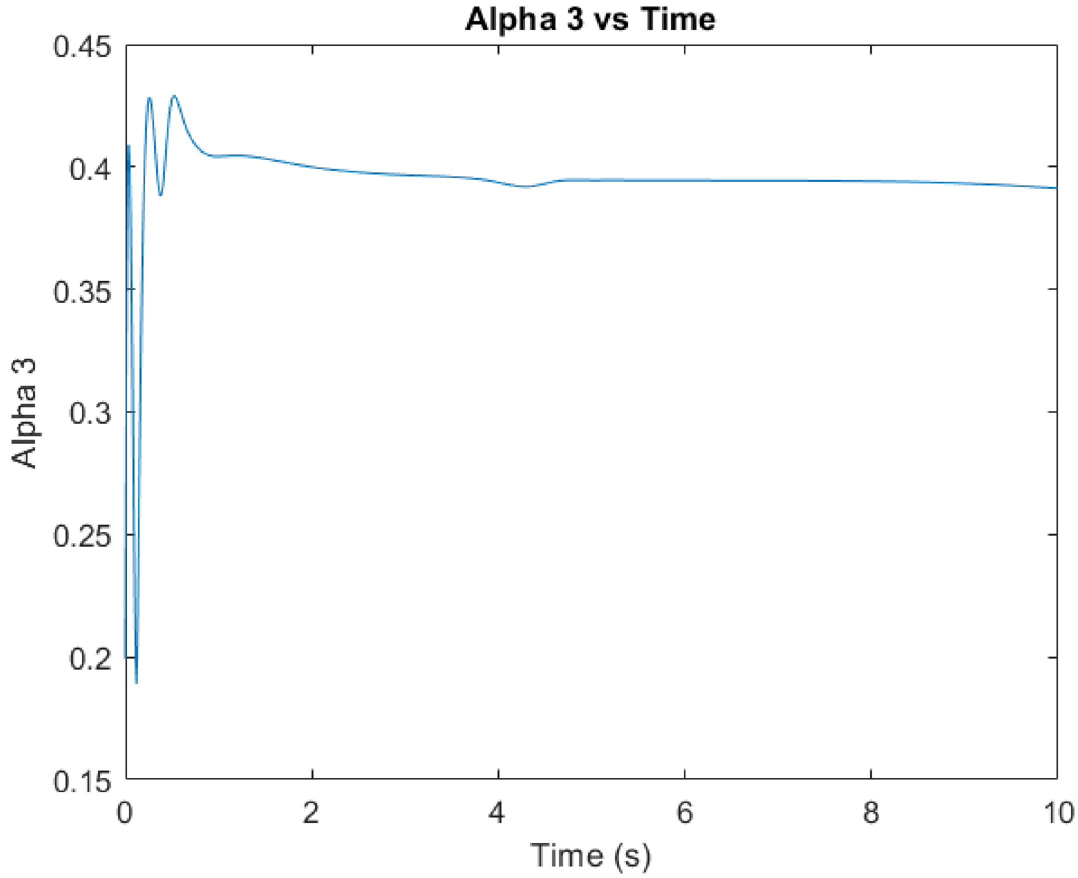


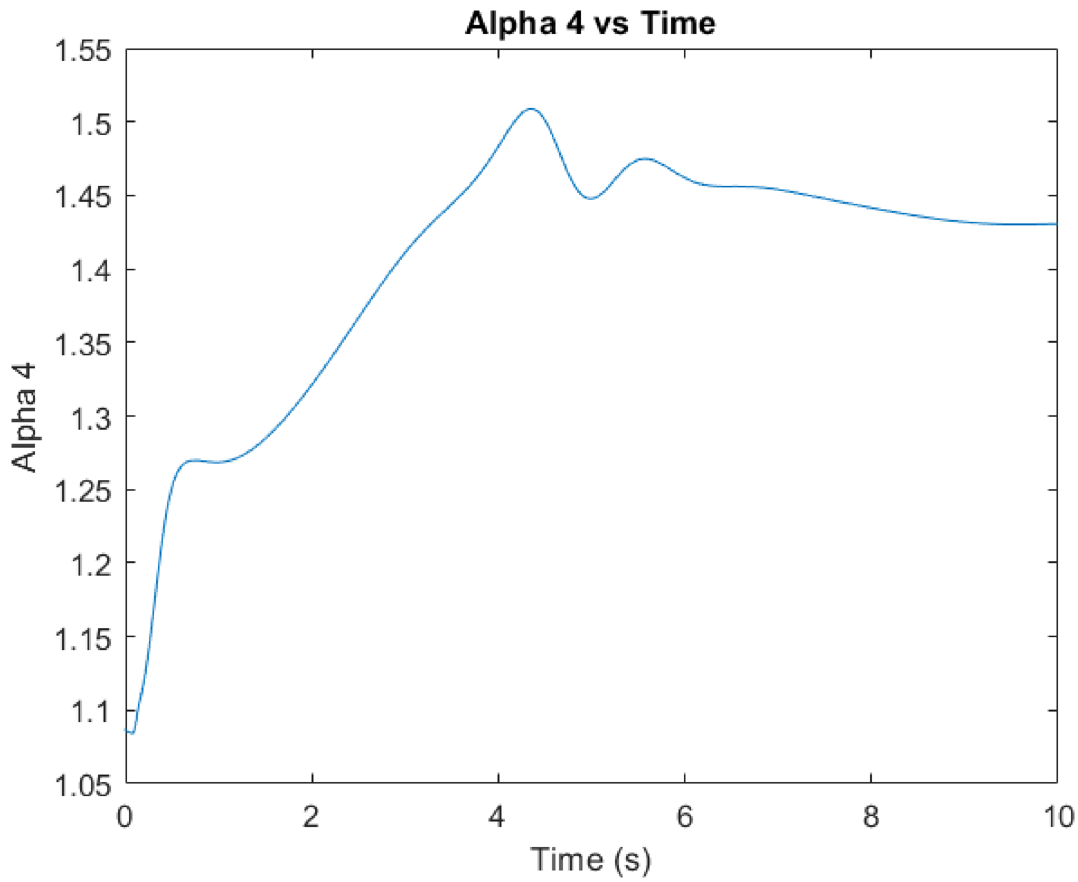

theta1dot
theta1dot desired
Radian/sec
time (sec)
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0
2
4
6
8
10

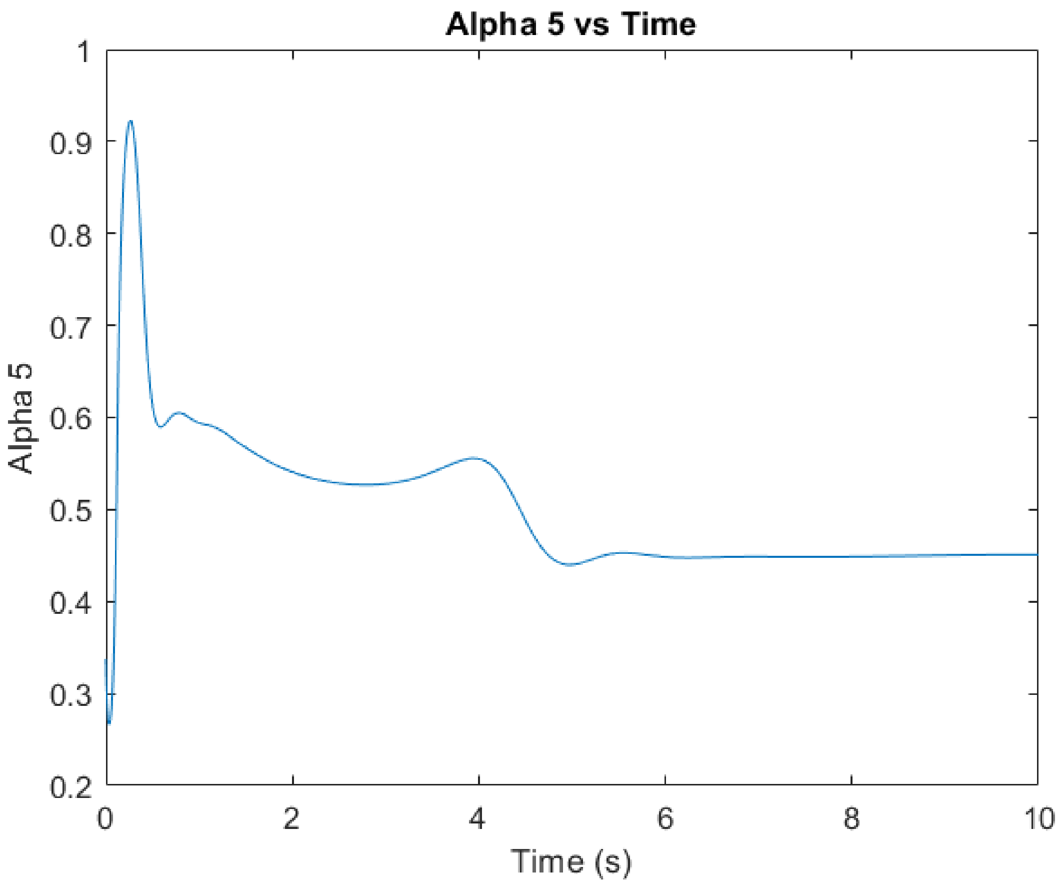

theta2dot
theta2dot desired
Radian/sec
time (sec)
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
2
4
6
8
10


Alpha 1 vs Time
1.21
1.2
1.19
1.18
1.17
1.16
1.15
1.14
Alpha 1
0
2
4
6
8
10
Time (s)

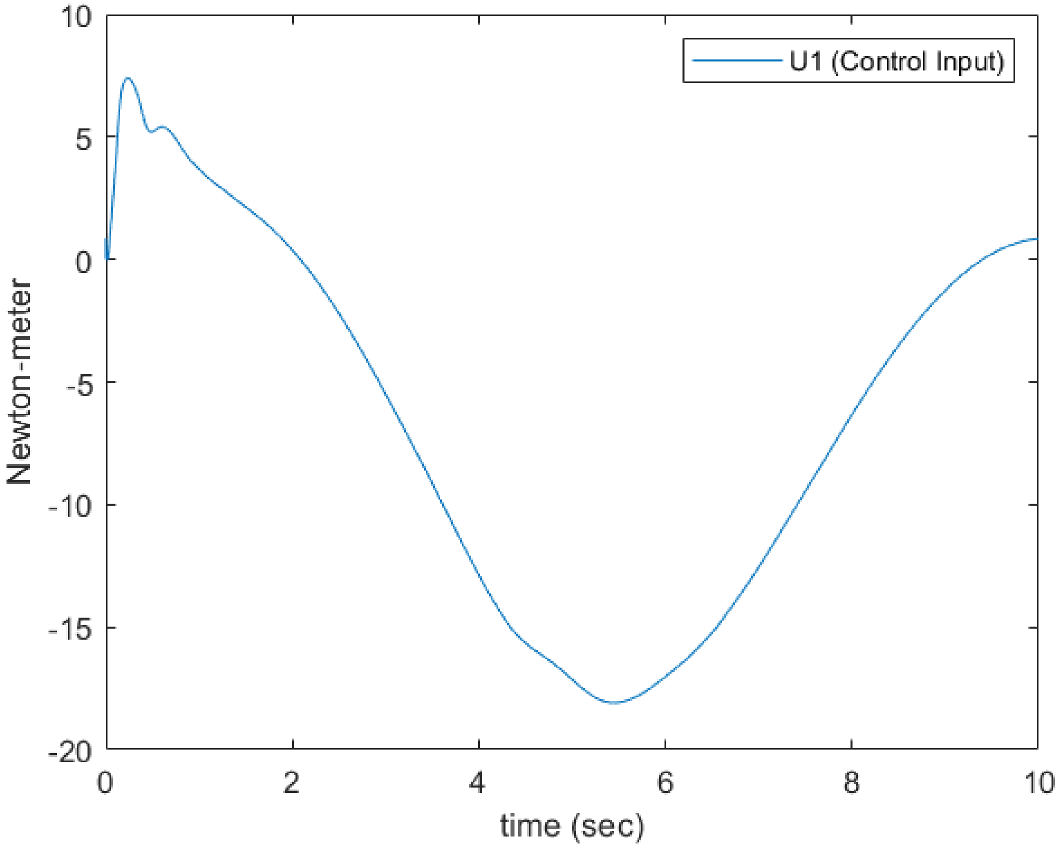

Alpha 2 vs Time
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Alpha 2
0
2
4
6
8
10
Time (s)


Alpha 3 vs Time
0.45
0.4
0.35
0.3
0.25
0.2
0.15
Alpha 3
0
2
4
6
8
10
Time (s)

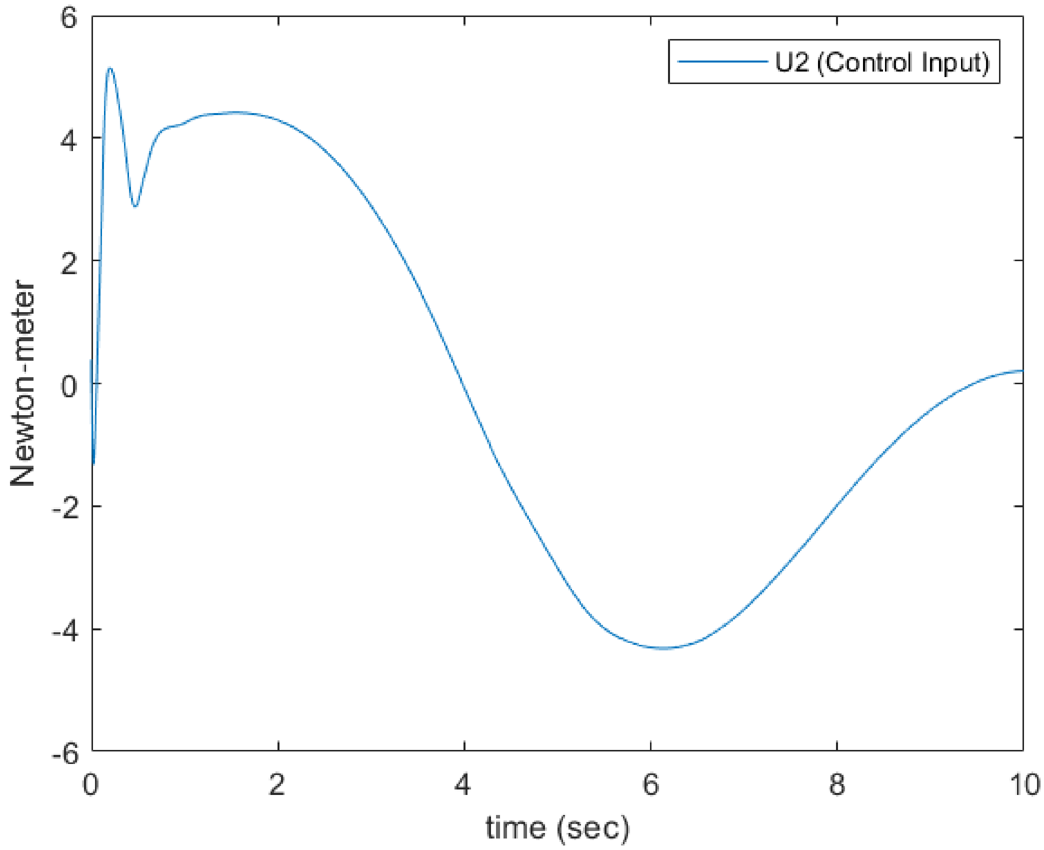

Alpha 4 vs Time
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
Alpha 4
0
2
4
6
8
10
Time (s)



Alpha 5 vs Time
Alpha 5
Time (s)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
2
4
6
8
10



U1 (Control Input)
Newton-meter
time (sec)
10
5
0
-5
-10
-15
-20
0
2
4
6
8
10



Discussion : As seen from the plots above, when the adaptive inverse dynamics control law is not used,i.e the P matrix = 0, the plots might converge but the actual values tend to deviate a lot from the actual values.