Table of Contents


```
clc;
clear all;
close all;
tic
```

generate data

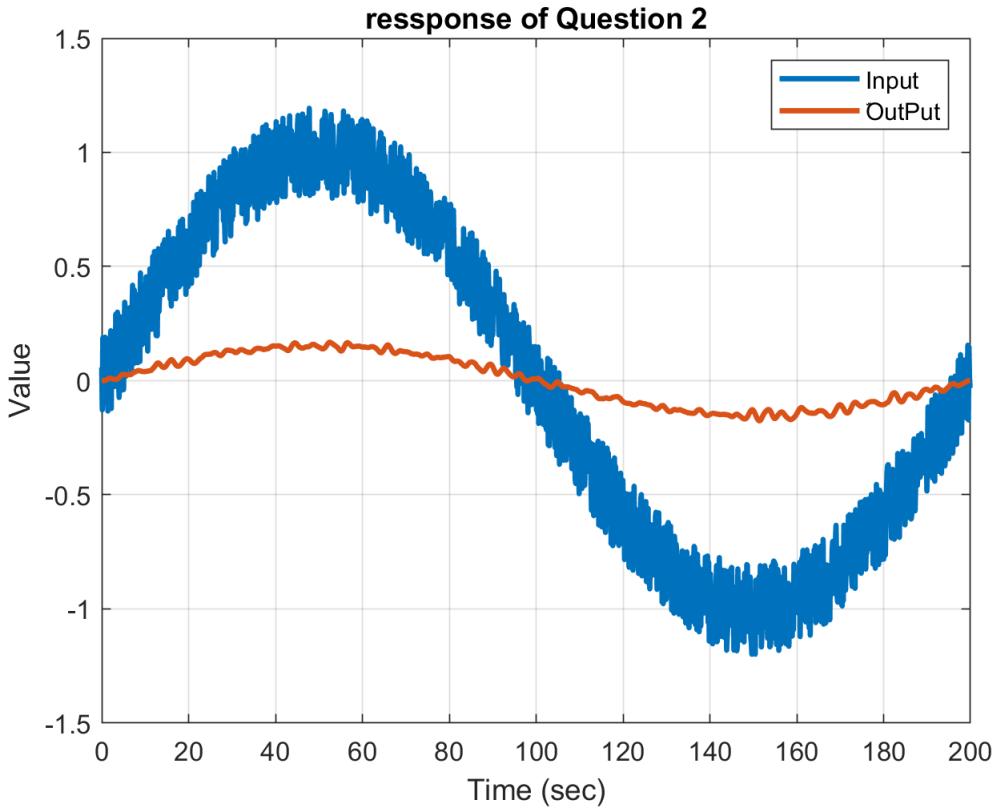
```
run ("Basics.m")
```

```
sys =

                 1.3 s + 1.333
  ------------------------------------------
  s^4 + 3.967 s^3 + 8.41 s^2 + 10.62 s + 8.756

Continuous-time transfer function.
fb = 2.4327
sysd =

  0.0004236 z^3 + 0.001167 z^2 - 0.000997 z - 0.0003069
  -----------------------------------------------------
      z^4 - 3.481 z^3 + 4.58 z^2 - 2.697 z + 0.5991

Sample time: 0.12914 seconds
Discrete-time transfer function.
c = 1×5
         0    0.0004    0.0012   -0.0010   -0.0003
d = 1×5
    1.0000   -3.4807    4.5802   -2.6968    0.5991
```

```
tfinal=200;
t = 0:T_s:tfinal;
u = zeros(numel(t),1);
```

General Input+white Noise

```
u = gensig('sine' , tfinal , tfinal ,T_s);
Noise=-0.2+(0.2+0.2)*rand(numel(t),1);
u=u+Noise;
y = lsim(sysd  ,u ,t);
plot(t,u ,t , y ,'LineWidth',2) ;
xlabel('Time (sec)') ;
ylabel('Value') ;
title('ressponse of Question 2') ;
grid on
legend('Input' , 'OutPut') ;
```



Recursive Least Square estimation

```
N = numel(y) ;
%choose number of parameters
Parameters_in_den=4
```

```
Parameters_in_den = 4
```

```
Parameters_in_num=4
```

```
Parameters_in_num = 4
```

```
Nv=Parameters_in_num+Parameters_in_den
```

```
Nv = 8
```

```
theta(:,1:Nv) = zeros(Nv , Nv) ;
P = 1e12*eye(Nv) ;
phi=[];

Eror=zeros(1,N);
for i = (max(Parameters_in_num,Parameters_in_den)+1):N
    phi(:,i) = [(y(i-1:-1:i-Parameters_in_den))' , (u(i-1:-1:i-Parameters_in_num))'];
    K = P*phi(:,i)*(1+phi(:,i)'*P*phi(:,i))^(-1) ;
    P = (eye(Nv) - K*phi(:,i)')*P ;
    theta(:,i) = theta(:,i-1) + K*(y(i) - phi(:,i)'*theta(:,i-1));
    Eror(i)=(Eror(i-1)+(y(i)-phi(:,i)'*theta(:,i))^2);
end
```

BODE

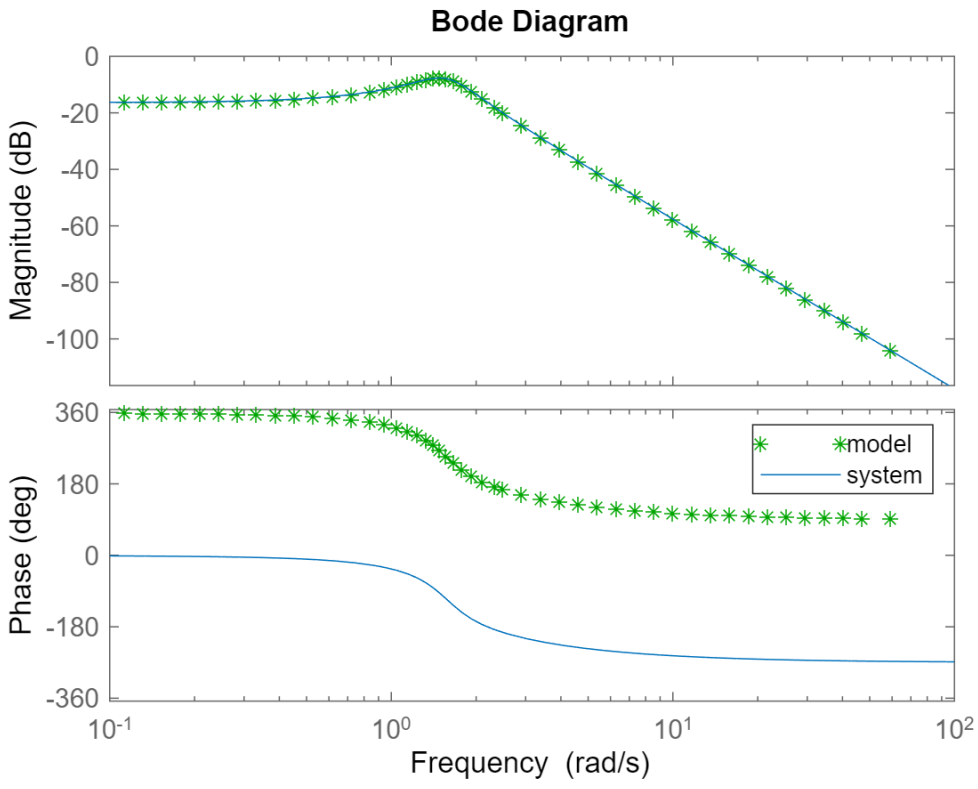
```
ident_dis = tf(theta((Parameters_in_num+1):end,end)' ,[1 -theta(1:Parameters_in_num ,end)'], T_
```

```
ident_dis =

  0.0004236 z^3 + 0.001167 z^2 - 0.0009969 z - 0.0003069
  ------------------------------------------------------
      z^4 - 3.481 z^3 + 4.58 z^2 - 2.697 z + 0.5991

Sample time: 0.12914 seconds
Discrete-time transfer function.
```

```
ident_analog = d2c(ident_dis)
```

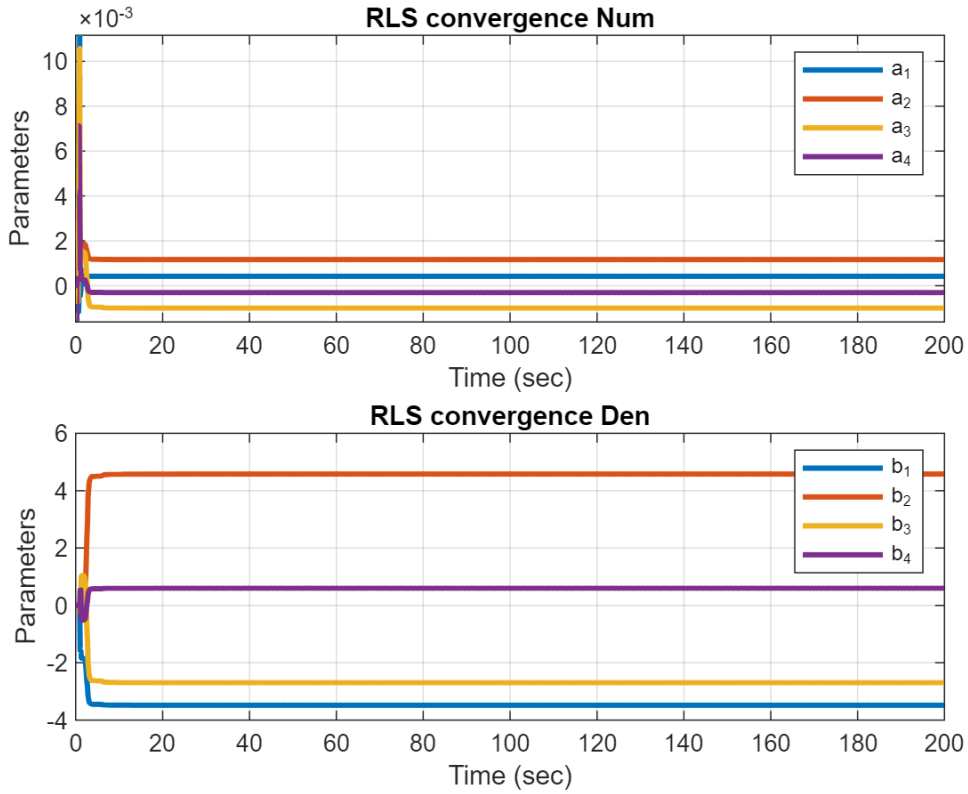
```
ident_analog =

  -6.809e-09 s^3 + 1.409e-07 s^2 + 1.3 s + 1.334
  ----------------------------------------------
  s^4 + 3.967 s^3 + 8.411 s^2 + 10.62 s + 8.758

Continuous-time transfer function.
```

```
bode(ident_analog ,'g*',sys)
legend('model ','system')
```



RLS Convergence

```
subplot(2,1,1)
plot(t , theta((Parameters_in_num+1):end,:) , 'LineWidth' , 2) ;
xlabel('Time (sec)') ;
ylabel('Parameters') ;
title('RLS convergence Num') ;
grid on
legend('a_1','a_2','a_3','a_4')
% xlim([0 6])
% ylim([-0.5 0.5])
%-------------------------------------------------------------
subplot(2,1,2)
plot(t , -theta(1:Parameters_in_num ,:) , 'LineWidth' , 2) ;
xlabel('Time (sec)') ;
ylabel('Parameters') ;
title('RLS convergence Den') ;
grid on
legend('b_1','b_2','b_3','b_4')
```

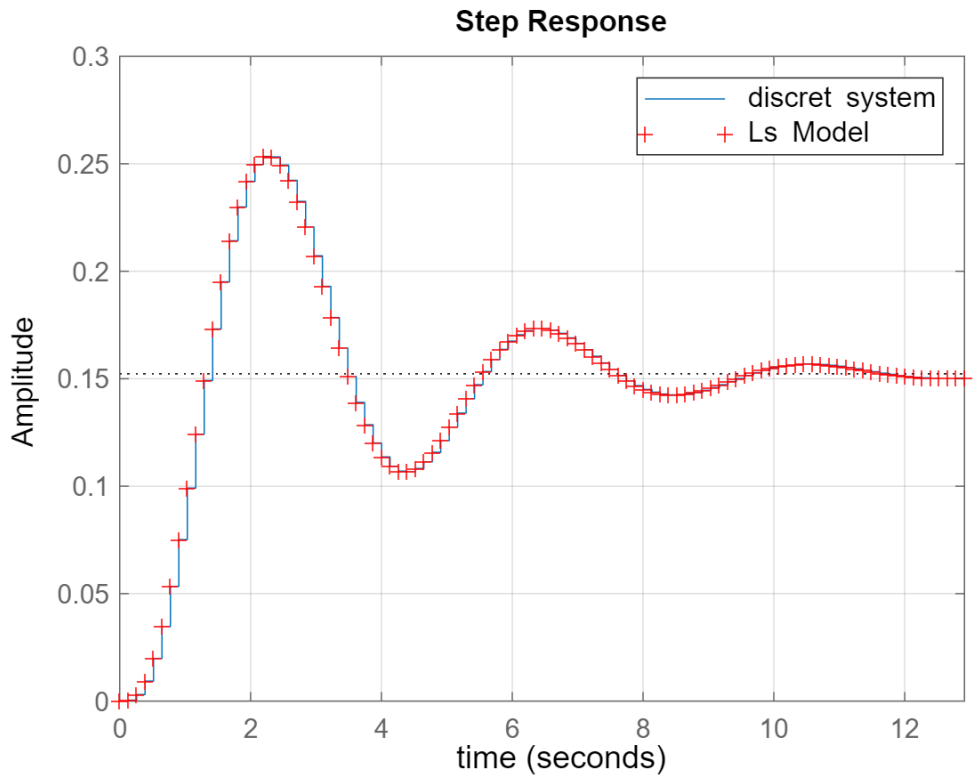



```
% xlim([0 6])
% ylim([-2 2])
```

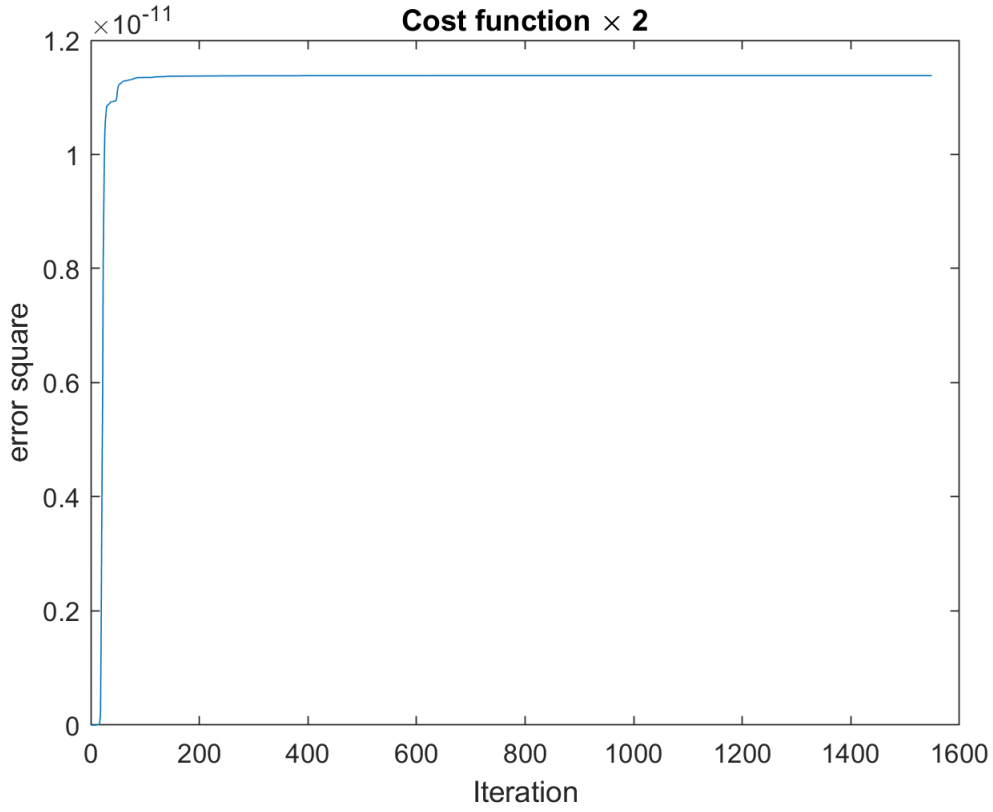
Ploting discret system and Least square Model via step input

```
figure
step(sysd,0:T_s:100*T_s)
hold on
step(ident_analog,0:T_s:100*T_s,'r+')
legend('\fontsize{12} discret system','\fontsize{12} Ls Model');
```

```
grid on;
xlabel('time','fontsize',12);
```




```
figure
plot(Eror)
xlabel('Iteration') ;
ylabel('error square') ;
title('Cost function \times 2') ;
```




```
toc
```

```
Elapsed time is 11.035141 seconds.
```