

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

## 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 = 1x5
```

```
    0    0.0004    0.0012   -0.0010   -0.0003
```

```
d = 1x5
```

```
    1.0000   -3.4807    4.5802   -2.6968    0.5991
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
tfinal=200;
```

```
t = 0:T_s:tfinal;
```

```
u = gensig('sine' , tfinal/20 , tfinal ,T_s);%+gensig('sine' , tfinal/50 , tfinal ,T_s)+gensig('sine' , tfinal/10 , tfinal ,T_s)
```

```
Noise=[1:numel(t)];
```

```
Noise(1:10) = ones(1,10)';
```

```
for i=4:1:numel(t)
```

```
    Noise(i)=+0.4*Noise(i-1)+0.75*Noise(i-2)-0.15*Noise(i-3);
```

```
end
```

```
Noise2=-0.2+(0.2+0.2)*rand(numel(t),1);
```

```
u=u+Noise'+Noise2;
```

```
y = lsim(sysd ,u ,t);
```

```
plot(t,u ,t , y , 'LineWidth',2) ;
```

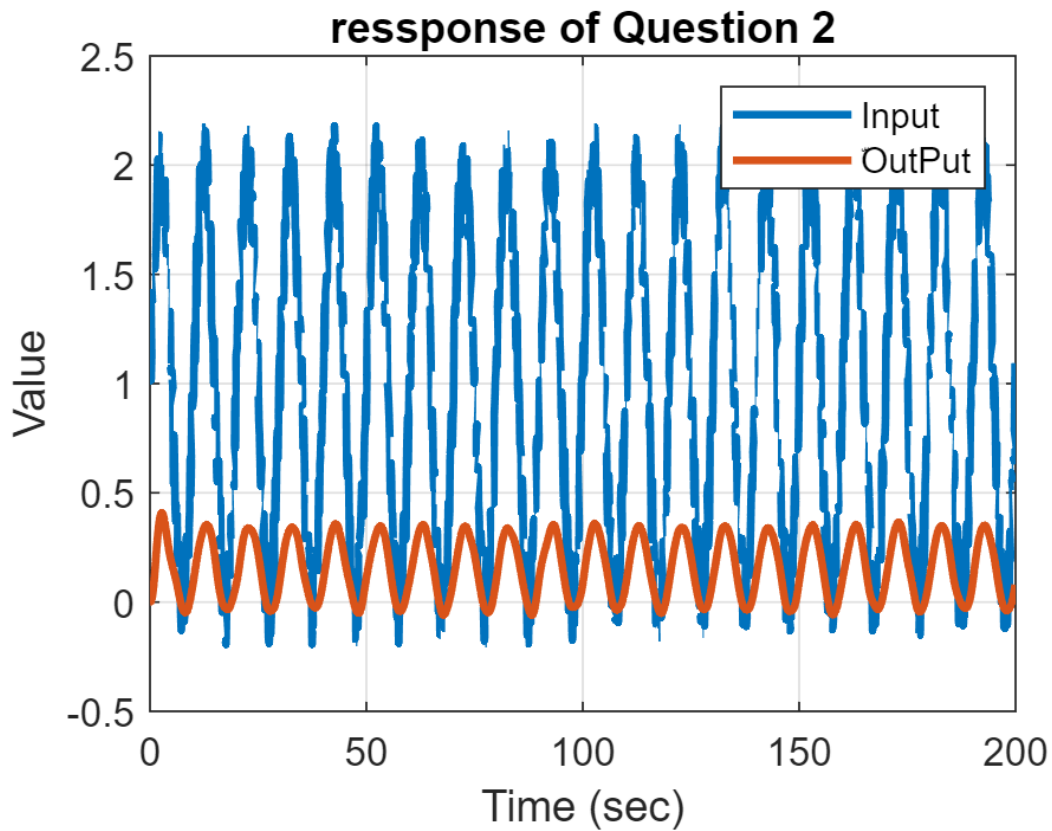
```
xlabel('Time (sec)') ;
```

```
ylabel('Value') ;
```

```
title('response of Question 2') ;
```

```
grid on
```

```
legend('Input' , 'OutPut') ;
```



## recursive least esquare estimation

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

```
Parameters_in_den = 4
```

```
Parameters_in_num=4
```

```
Parameters_in_num = 4
```

```
Parameters_in_noise=3
```

```
Parameters_in_noise = 3
```

```
Nv=Parameters_in_num+Parameters_in_den+Parameters_in_noise;
P = 1e12*eye(Nv) ;
theta=[Nv,N]
```

```
theta = 1x2
      11      1549
```

```
theta(1:Nv,1:30) = 5*ones(Nv,30) ;
e=[numel(y),1]
```

```
e = 1x2
    1549      1
```

```
e=zeros(numel(y),1)
```

```
e = 1549×1
    0
    0
    0
    0
    0
    0
    0
    0
    0
    0
    :
```

```
phi=[];
Error=zeros(1,N)
```

```
Error = 1×1549
    0    0    0    0    0    0    0    0    0    0    0    0...
```

```
tic
```

```
for i = (max(Parameters_in_num,Parameters_in_den+Parameters_in_noise))+1:N
    phi(:,i) = [[y(i-1:-1:i-Parameters_in_den)]' , [u(i-1:-1:i-Parameters_in_num)]' , [e(i-1:-1:i-Parameters_in_noise)]'];
    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));
    Error(i)=(Error(i-1)+(y(i)-phi(:,i)'*theta(:,i))^2);
end
```

## Code

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

```
ident_dis =
```

$$\frac{0.0004236 z^3 + 0.001167 z^2 - 0.000997 z - 0.0003069}{z^4 - 3.481 z^3 + 4.58 z^2 - 2.697 z + 0.5991}$$

Sample time: 0.12914 seconds  
Discrete-time transfer function.

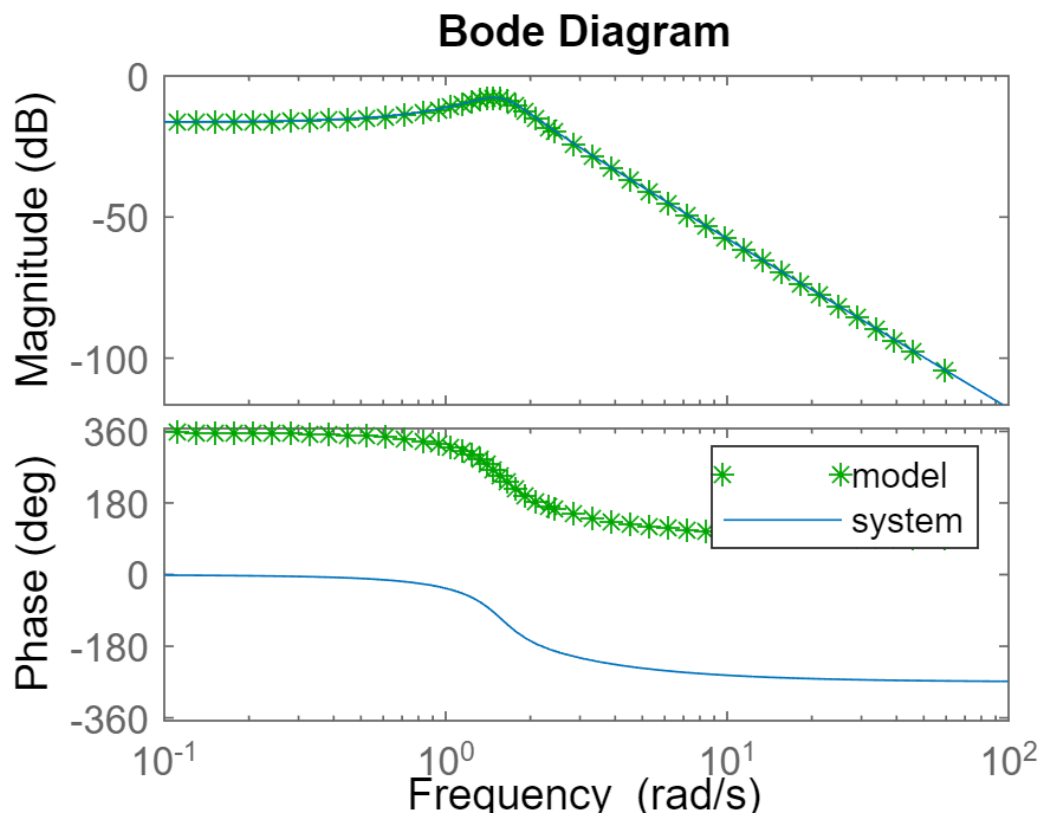
```
ident_analog = d2c(ident_dis)
```

```
ident_analog =
```

$$\frac{3.925e-11 s^3 - 2.395e-08 s^2 + 1.3 s + 1.333}{s^4 + 3.967 s^3 + 8.41 s^2 + 10.62 s + 8.756}$$

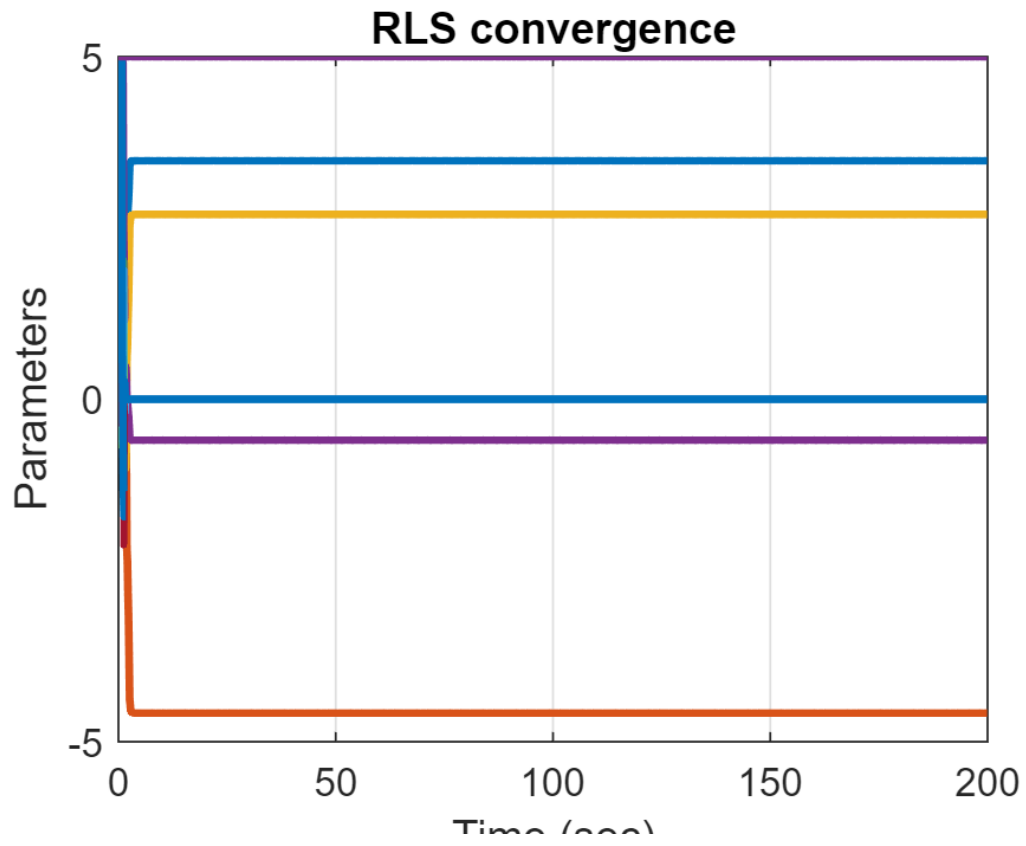
Continuous-time transfer function.

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

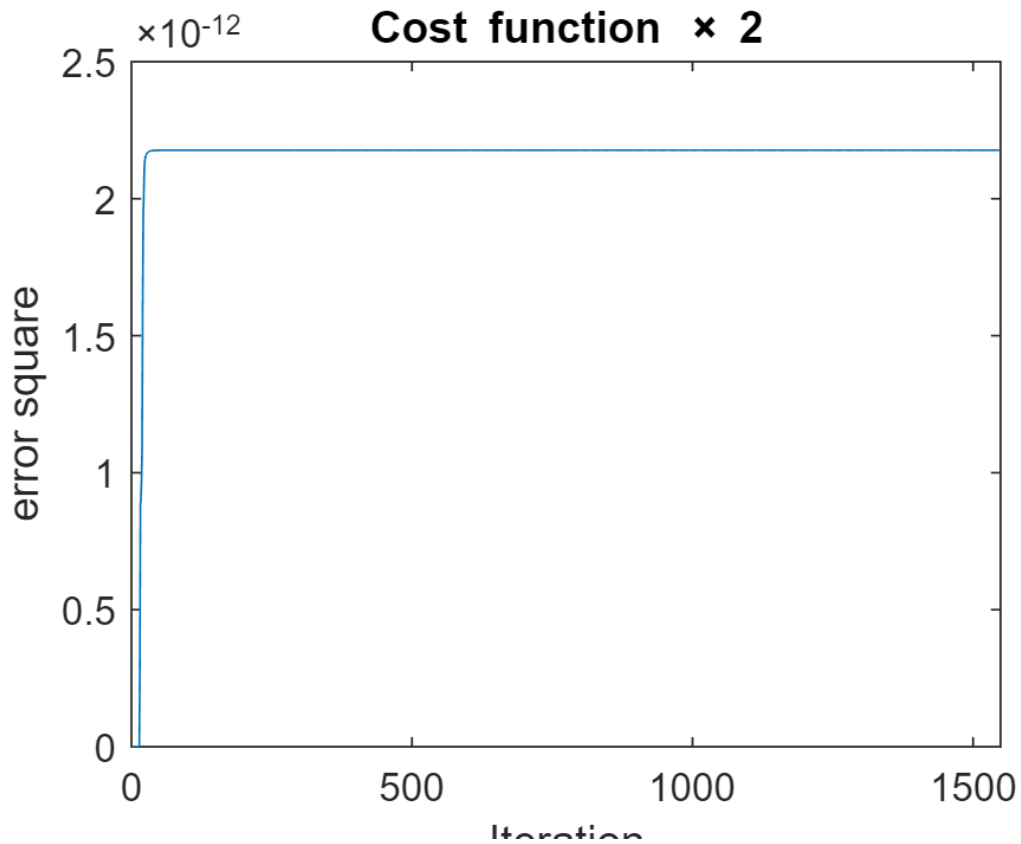


RLS Convergence

```
plot(t , theta(:,:) , 'LineWidth' , 2) ;  
xlabel('Time (sec)') ;  
ylabel('Parameters') ;  
title('RLS convergence') ;  
grid on
```



```
plot(1:1:N,Error)
xlabel('Iteration') ;
ylabel('error square') ;
title('Cost function \times 2') ;
```



```
tfinal=1000;
T_s=T_s
```

```
T_s = 0.1291
```

```
t = 0:T_s:tfinal;
u = gensig('square' , tfinal/20 , tfinal ,T_s);
u = u+rand(numel(t),1);
y = lsim(sysd,u ,t);

y_model = lsim(ident_dis ,u ,t);

plot(t,y_model , 'b*',t , y , 'LineWidth',1.25) ;
xlabel('Time (sec)') ;
ylabel('Value') ;
title('response of Question 2') ;
grid on
legend('Under parameter Model' , 'System') ;
```

