

```
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);
```

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

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

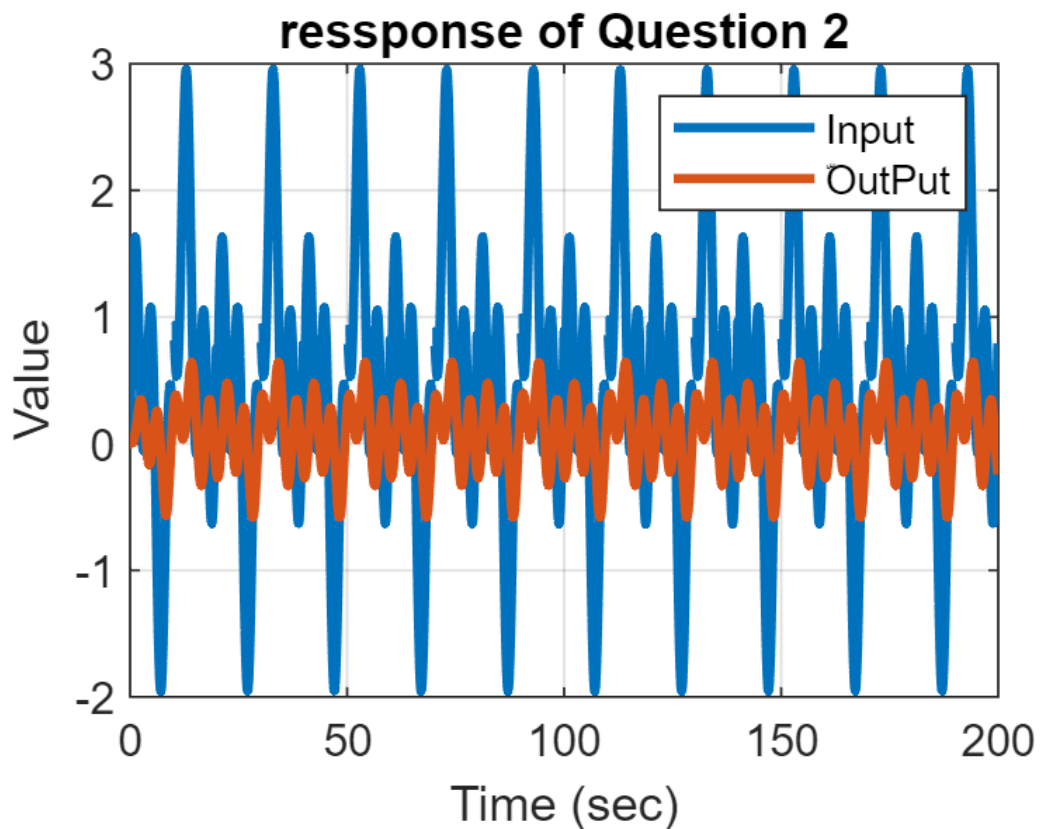
```
xlabel('Time (sec)') ;
```

```
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
```

```
Nv=Parameters_in_num+Parameters_in_den
```

```
Nv = 8
```

```
% Nv = 10 ;
P = 1e12*eye(Nv) ;
theta=[Nv,N]
```

```
theta = 1×2
      8      1549
```

```
theta(1:Nv,1:30) = -1e2*ones(Nv,30) ;
```

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

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

```

tic
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));
    Error(i)=(Error(i-1)+(y(i)-phi(:,i)'*theta(:,i))^2);
end
toc

```

Elapsed time is 0.035072 seconds.

## Bode

```

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

```

```

ident_dis =

      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 =

      1.328e-09 s^3 - 7.318e-09 s^2 + 1.3 s + 1.333
-----
      s^4 + 3.967 s^3 + 8.41 s^2 + 10.62 s + 8.756

```

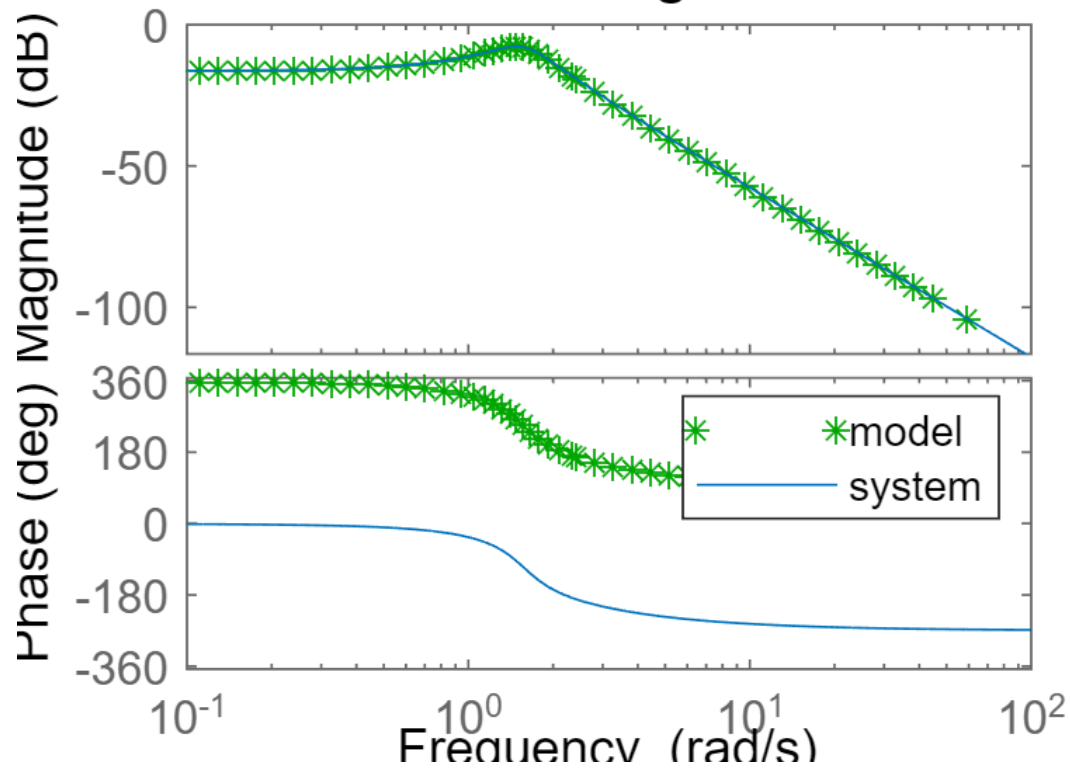
Continuous-time transfer function.

```

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

```

## Bode Diagram



## RLS Convergence

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

