```
clc;
clear ;
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 = 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 = gensig('sine' , tfinal/20 , tfinal ,T_s)+gensig('sine' , tfinal/50 , tfinal ,T_s)+gensig('s
Noise2=-0.2+(0.2+0.2)*rand(numel(t),1);
u=u+Noise2;
y = lsim(sysd  ,u ,t);
for i=1:numel(t)
    paras(:,i)=[d(2:end),c]';
end
uu=300;
```

sudden parameter resetting

```
for temp=uu:numel(y)
    if floor(temp/100)==temp/100
        cc= c(2:end)+c(2:end)*(rand);
        dd=d(2:end)+d(2:end)*(rand);
        paras(:,temp)=[dd,0,cc]';
    end

    y(temp)=[-(y(temp-1:-1:temp-4))',(u(temp-1:-1:temp-4))']*[dd,cc]';
end
    sys_dis = tf(dd ,[1 -cc], T_s)
```

```
sys_dis =

          -3.842 z^3 + 5.056 z^2 - 2.977 z + 0.6614
  ------------------------------------------------------------
  z^4 - 0.0004369 z^3 - 0.001204 z^2 + 0.001028 z + 0.0003165

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

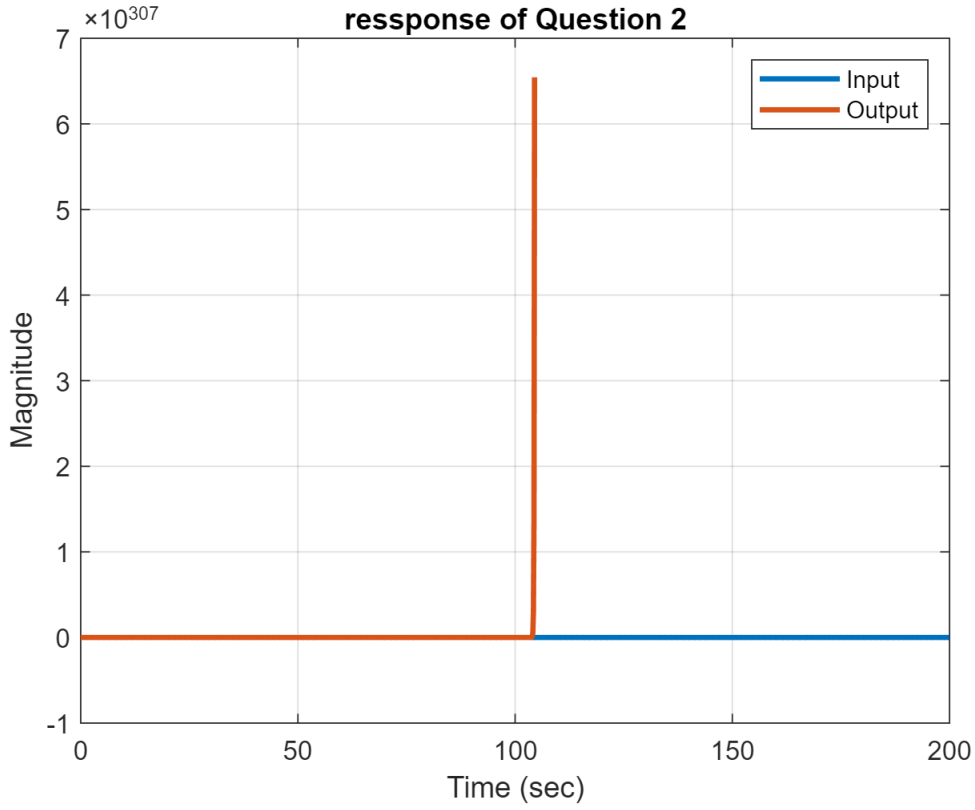
```
ident_change = d2c(sys_dis)
```

```
ident_change =

  -4106 s^3 - 9.739e04 s^2 - 7.699e05 s - 1.843e05
  ------------------------------------------------
  s^4 + 62.4 s^3 + 1865 s^2 + 2.744e04 s + 1.672e05

Continuous-time transfer function.
```

smooth parameter variation

```
% for temp=uu:numel(y)
%     paras(:,temp)=[d(2:end)+d(2:end)*.005*(sin((temp-uu)/2)),(c+c*.5*(sin((temp-uu)/2)-1))]';
%     y(temp)=[-(y(temp-1:-1:temp-4))',(u(temp:-1:temp-4))']*paras(:,temp);
% end
%     sys_dis = tf(c+c*.01*(sin(.01*(temp-uu))-1)' ,[1 -d(2:end)+d(2:end)*.001*(sin(.01*(temp-u
%     ident_change = d2c(sys_dis)
```

```
plot(t,u ,t , y ,'LineWidth',2) ;
xlabel('Time (sec)') ;
ylabel('Magnitude') ;
title('ressponse of Question 2') ;
grid on
legend('Input','Output') ;
```



Lanmbda-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
```

```
% Nv = 10 ;
theta(:,1:Nv) = zeros(Nv , Nv) ;
P = 1e12*eye(Nv) ;
phi=[];
Eror=zeros(1,N);
norm=zeros(N,1);
y_hat(1:N,1)=zeros(N,1);
Step=-0.1:0.002:0
```

```
Step = 1×51
   -0.1000   -0.0980   -0.0960   -0.0940   -0.0920   -0.0900   -0.0880   -0.0860 ···
```

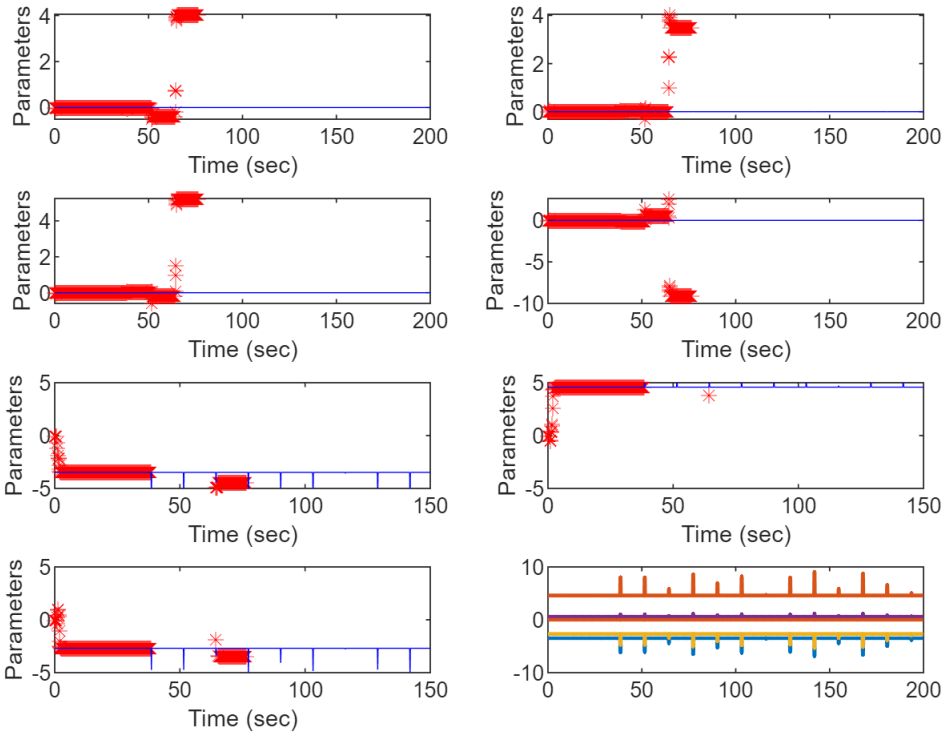
```
lambda=exp(Step)
```

```
lambda = 1×51
    0.9048    0.9066    0.9085    0.9103    0.9121    0.9139    0.9158    0.9176 ···
```

```
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)*((lambda(mod(i,numel(Step)-1)+1))+phi(:,i)'*P*phi(:,i))^(-1) ;
    P = (eye(Nv) - K*phi(:,i)')*P/lambda(mod(i,numel(Step)-1)+1) ;
    y_hat(i)=phi(:,i)'*theta(:,i-1);
    theta(:,i) = theta(:,i-1) + K*(y(i)-y_hat(i));
    norm(i)=(norm(i-1)+(y(i)-phi(:,i)'*theta(:,i))^2)/2;
    Eror(i)=(Eror(i-1)+(y(i)-phi(:,i)'*theta(:,i))^2);
end
```

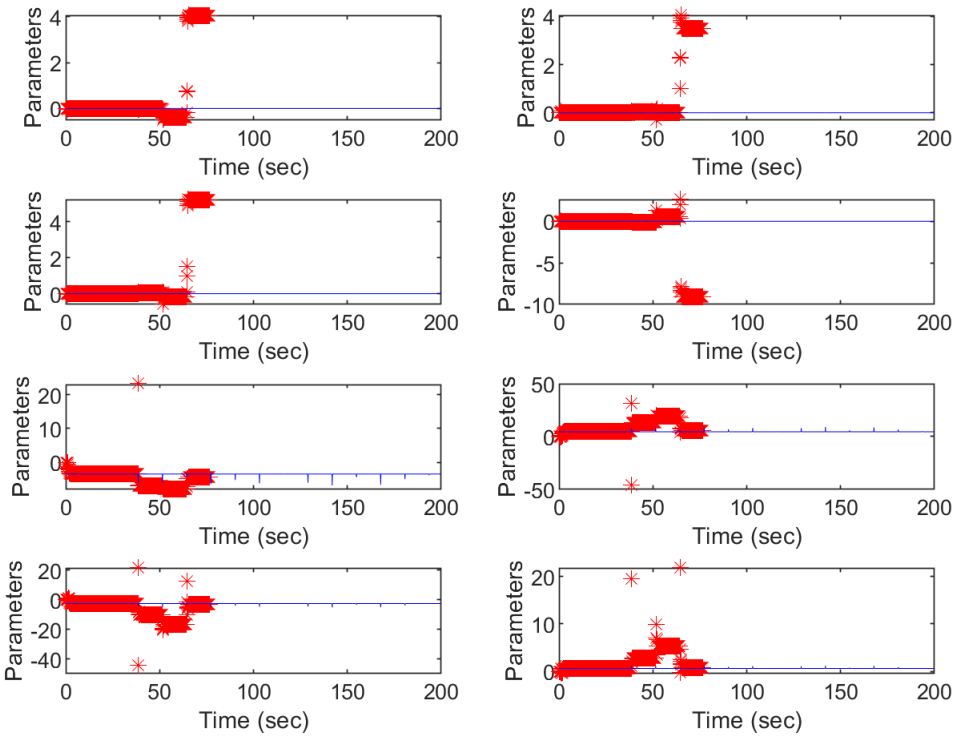
RLS Convergence

```
plot(t ,paras(:,:) , 'LineWidth' , 1.5)
```

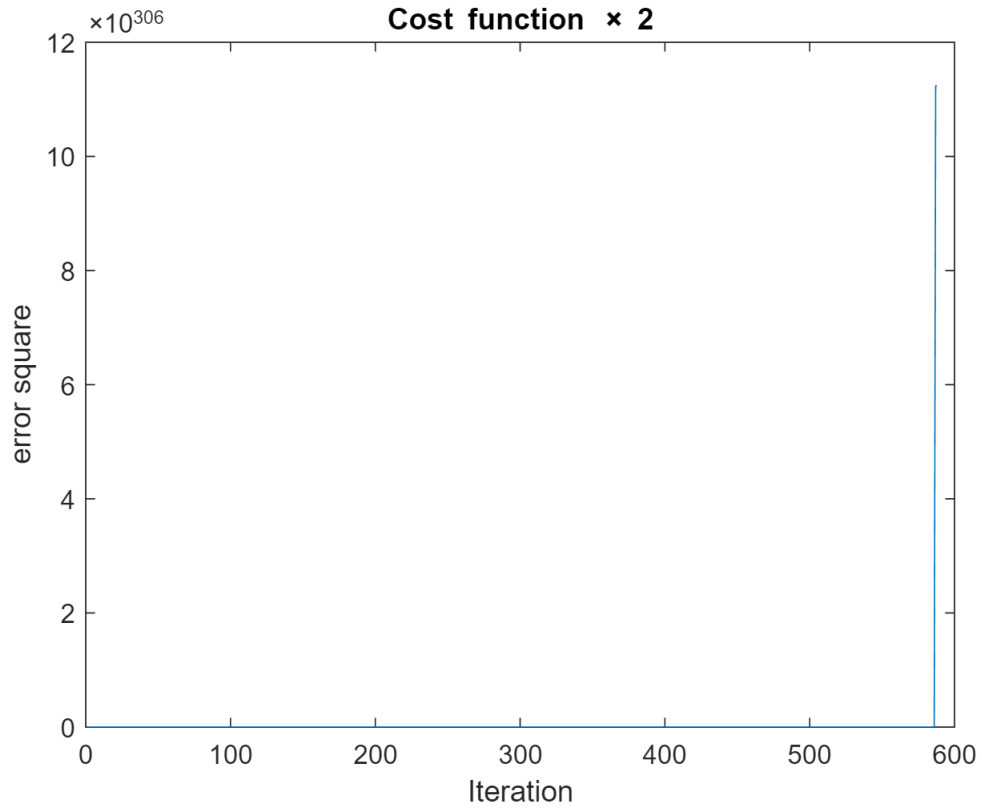



```
figure
grid on
for i=1:4
    subplot(4,2,i)
    plot(t , theta(4+i,:),'r*' ,t , paras(5+i,:) ,'b','LineWidth' , 0.25) ;
    xlabel('Time (sec)') ;
    ylabel('Parameters') ;
%     xlim([0 150])
%     ylim([-0.01  0.03])
end
for i=1:4
```

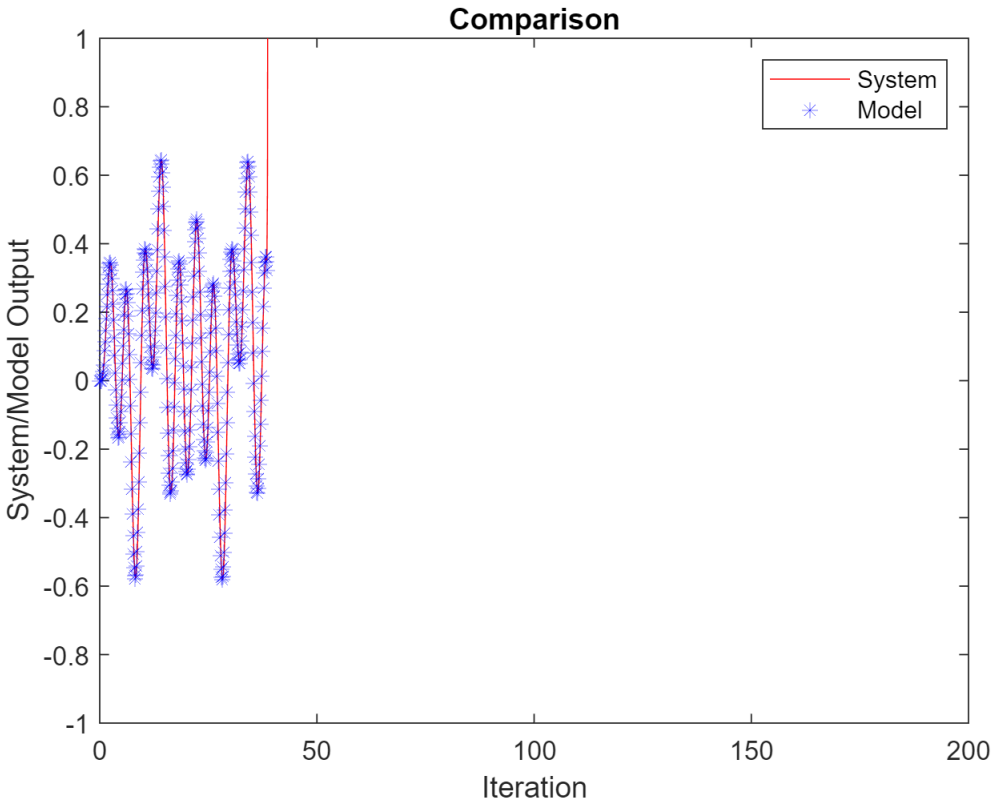
```
    subplot(4,2,4+i)
    plot(t , -theta(i,:) ,'r*',t , paras(i,:) ,'b', 'LineWidth' , 0.25) ;
    xlabel('Time (sec)') ;
    ylabel('Parameters') ;
%       xlim([0 150])
%       ylim([-5  5])
end
```




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




```
plot(t,y,'r',t,y_hat,'b*','LineWidth',0.15)
xlabel('Iteration') ;
ylabel('System/Model Output') ;
title('Comparison') ;
xlim([0 200])
ylim([-1 1])
legend('System','Model')
```


Comparison
System
Model
System/Model Output
Iteration
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
50
100
150
200