ELEC4632 lab 2

```matlab
clear
close all
clc
load SysIdenData_8.mat
t = LogData.time;
y_act = LogData.signals(1).values(:,2);
y_actm = LogData.signals(1).values(:,1);
u_act = LogData.signals(2).values;
figure()
plot(y_act)
% truncate the first period, keep data afer 800.25 seconds
index = find(t==800.25);
y_act = y_act(index:end);
y_actm = y_actm(index:end);
u_act = u_act(index:end);
t = t(1:length(u_act));
Ts = (t(end)-t(1))/(length(t)-1); % find sampling time
%Ts = t(2)-t(1);
fprintf('sampling time according to calculation is %d\n',Ts);
figure()
subplot(2,1,1)
hold on
plot(t,y_act,'b');

xlabel('Time (sec)');
ylabel('WaterLevel (V)');
title('Actual signal');
grid on
plot(t,y_actm,'r');
legend('Noised-Reduced Output','Measured Output');
hold off
subplot(2,1,2)
plot(t,u_act);
xlabel('Time (sec)');
ylabel('Pump voltage (V)');
title('Actual Input Signal');
legend('Actual input');
ylim([0 2.5]);
grid on

% remove input offset
u_offset = u_act(1);
u = u_act - u_offset;
figure()
subplot(2,1,2)
plot(t,u)
xlabel('Time (sec)');
ylabel('Pump Voltage (V)');
title('Actual Offset-Free Input Signal');
ylim([-0.5 0.5])
```

```matlab
legend('Actual Input');
grid on
% remove output offset
count = 0;
i = 1;
while(u_act(i+1) == u_act(i))
    i=i+1;
    count = count + 1;
end
y_offset = mean(y_act(1:count));
y = y_act - y_offset;
subplot(2,1,1);
plot(t,y,'r')
grid on
xlabel('Time (sec)');
ylabel('Water Level (V)');
title('Actual Offset-Free Output Signal');
legend('Actual Output');

N = round(length(y)/2);
% start from k = 10, k should be greater than 2
k = 10;
phi = zeros(length(k:N),4);

for i = k:N
    phi(i-k+1,1) = y(i-1);
    phi(i-k+1,2) = y(i-2);
    phi(i-k+1,3) = u(i-1);
    phi(i-k+1,4) = u(i-2);
end

theta_hat = inv(phi'*phi)*phi'*y(k:N);
a1 = -theta_hat(1);
a2 = -theta_hat(2);
b1 = theta_hat(3);
b2 = theta_hat(4);

%[a1,a2,b1,b2] = second_order_regression(k,y,u);
H = tf([b1 b2],[1 a1 a2],Ts);
fprintf('Info about second order state space model is below:\n');
sys = ss(H)

figure()
%simulate second half
subplot(2,1,1)
b = [b1 b2];
a = [1 a1 a2];
y_simulate_2nd_Half = filter(b,a,u(N:end));
plot(t(N:end),y_simulate_2nd_Half,'--');
hold on
plot(t(N:end),y(N:end),'r');
grid on
xlabel('Time (sec)');
ylabel('Water Level (V)');
```

```matlab
legend('Simulated Output','Actual Output');
title('Offset-Free Model Verification (2^{nd} Half)');
hold off
% simulate entire
subplot(2,1,2)
y_simulate_entire_2nd_order = filter(b,a,u);
plot(t,y_simulate_entire_2nd_order,'--');
hold on
plot(t,y,'r')
grid on
xlabel('Time (sec)');
ylabel('Water Level (V)');
legend('Simulated Output','Actual Output');
title('Offset-Free Model Verification (Entire)');

immse(y,y_simulate_entire_2nd_order)

close all
```

sampling time according to calculation is 7.500000e-01
Info about second order state space model is below:

sys =

* A =*
*   x1   x2*
*   x1   1.179   -0.4004*
*   x2   0.5   0*

* B =*
*   u1*
*   x1   0.25*
*   x2   0*

* C =*
*   x1   x2*
*   y1   0.09455   0.2652*

* D =*
*   u1*
*   y1   0*

Sample time: 0.75 seconds
Discrete-time state-space model.

ans =

*   0.0033*

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