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EE5322 – Intelligent Control Systems
Homework #2
4 February 2014

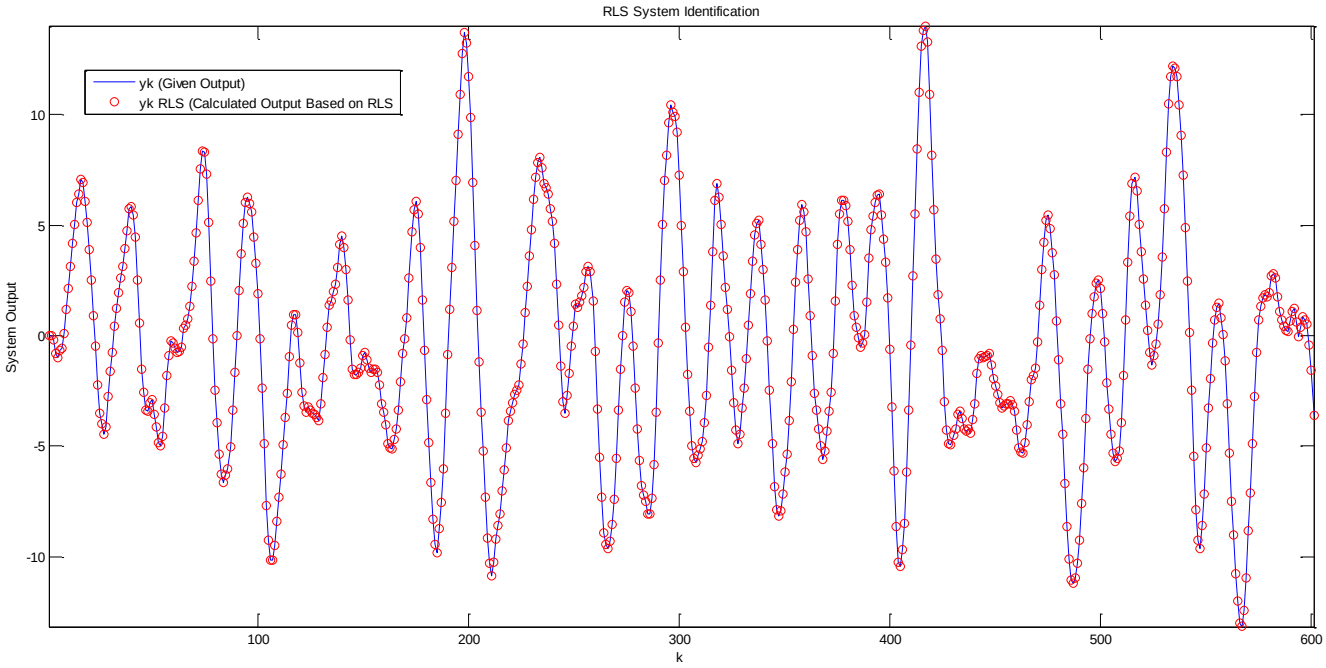
Problem 1

The transfer function coefficients are given below. Also, the plot shows a perfect match for the given outputs and the calculated outputs.

a1 = -1.8999
a2 = 0.9499
b0 = 0.2000

where,

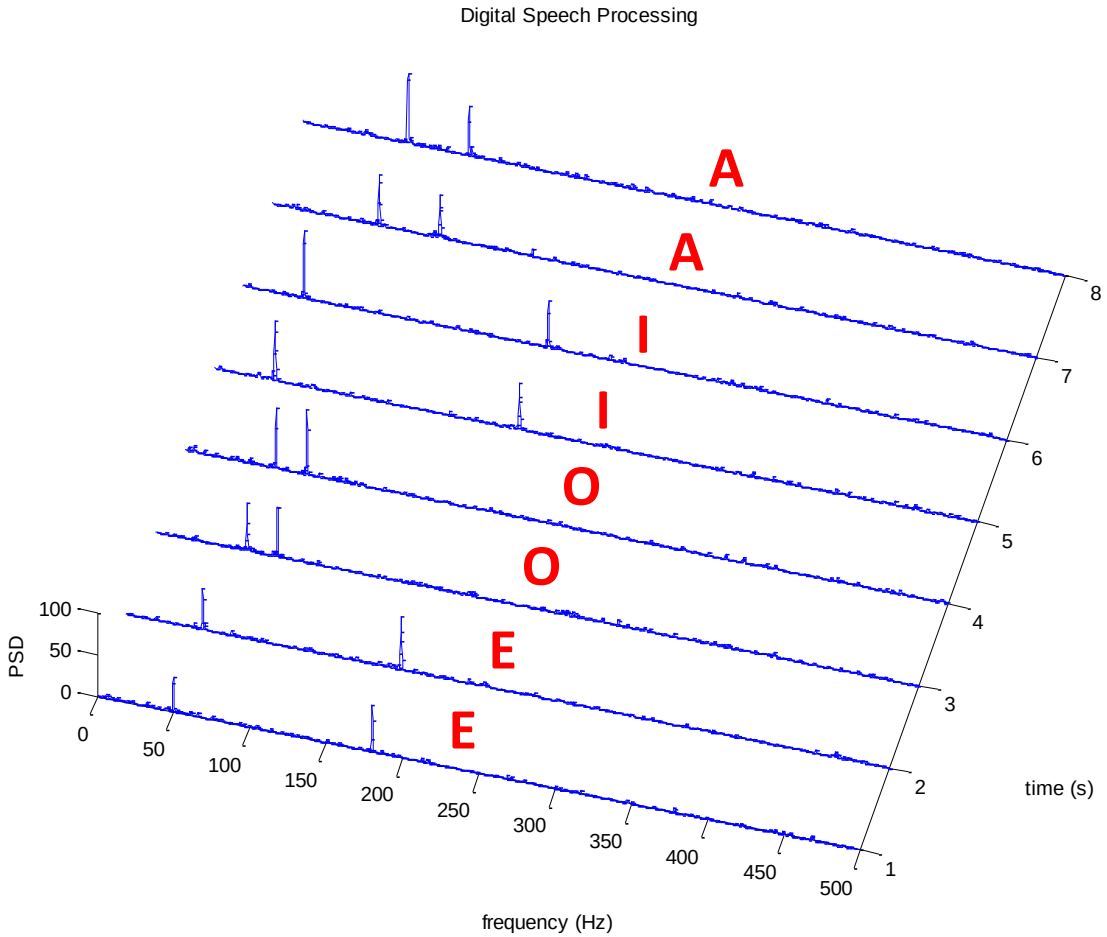
$$H(z) = \frac{b_0 z^{-2}}{1 + a_1 z^{-1} + a_2 z^{-2}} = \frac{b_0}{z^2 + a_1 z + a_2}$$



Problem 2

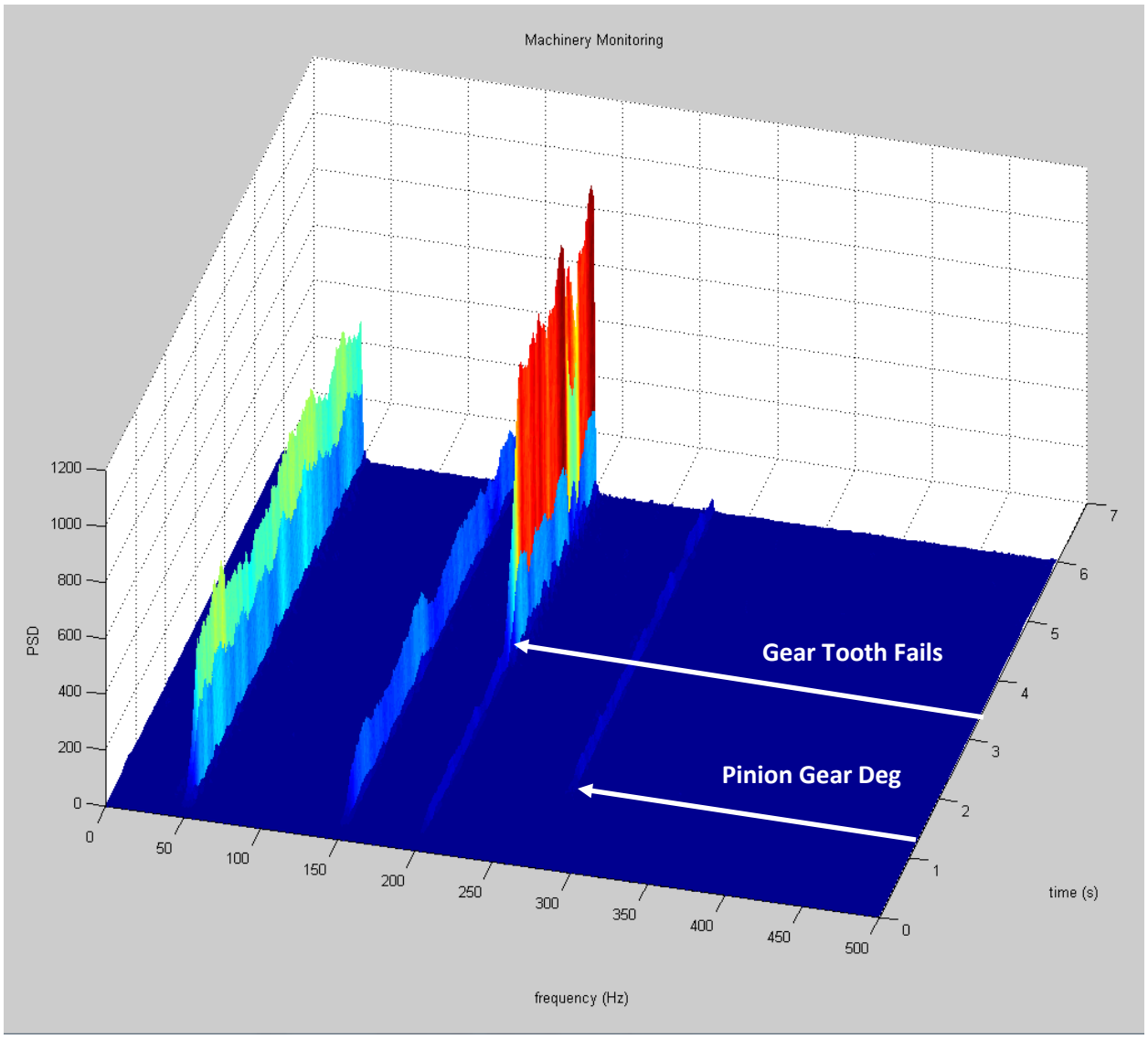
The vowels are at the following times:

E in 0 to 1 second time slot
E in 1 to 2 second time slot
O in 2 to 3 second time slot
O in 3 to 4 second time slot
I in 4 to 5 second time slot
I in 5 to 6 second time slot
A in 6 to 7 second time slot
A in 7 to 8 second time slot



Problem 3

Pinion gear degradation at approximately **1.14** seconds.
Gear tooth failure at approximately **3.119** seconds.



MATLAB Source Code

Problem 1

```
% EE5322 - Intelligent Control Systems
% HW2 - RLS and DFT Analyses
% David (Jerrod) English
% 10 February 2014

clear all; load('Prob1.mat');           % Import Data
u=Prob1(:,2); y=Prob1(:,3);

MA=y(1);                              % Initialize variables
VAR=0.001;
hk=[-y(1) 0 0]';
P=1000*eye(3);
theta_hat=[0 0 0]';

for k=1:length(y)-1                     % Recursion loop

    MA=MA+1/(k+1)*(y(k+1)-MA);
    VAR=VAR+1/(k+1)*(k/(k+1)*(y(k+1)-MA)^2-VAR);

    if k>1
       hk=[-y(k-1+1) -y(k-2+1) u(k-2+1)]';
    end

    K=P*hk*(hk'*P*hk+VAR)^(-1);                     % Kalman Gain
    P=(eye(3)-K*hk')*P;                             % Error Covariance
    theta_hat=theta_hat+K*(y(k+1)-hk'*theta_hat);   % Estimate

end

a1=theta_hat(1)             % Assign final estimate to TF coefficients
a2=theta_hat(2)
b0=theta_hat(3)

y_test(1)=0;                            % Initialize Test Output
y_test(2)=0;
for k=3:length(y)                       % Test output loop

    y_test(k)=-a1*y(k-1)-a2*y(k-2)+b0*u(k-2);

end

                                        %Comparison plot result

figure(1);plot(y); hold on; plot(y_test,'ro'); hold off;
title('RLS System Identification');xlabel('k'); ylabel('System Output');
legend('yk (Given Output)', 'yk RLS (Calculated Output Based on RLS');
axis tight;
```

Problem 2

```
% EE5322 - Intelligent Control Systems
% HW2 - RLS and DFT Analyses
% David (Jerrod) English
% 30 January 2014

clear all; load('Prob2.mat');                          % Import Data
k=Prob2(:,1); data=Prob2(1:end-1,2);                   % Remove last data pt

FFT_length=2^12;                                       % Set FFT length
Ts=0.001;                                              % Sampling period

w=2*pi/(FFT_length)*([1:FFT_length]-1);                % Frequency axis
f=w./(2*pi*Ts);
fhalf=f(1:length(f)/2);

figure(1)
for n=1:8                                              % Binned FFT's
    databin(:,n)=data(n*1000-999:n*1000);
    dftbin(:,n)=fft(databin(:,n),FFT_length);
    Power(:,n)=dftbin(:,n).*conj(dftbin(:,n))/FFT_length;
    hold on;
    plot3(fhalf',ones(FFT_length/2,1)*n,Power(1:FFT_length/2,n));
    hold off;
end
view(15,82);                                           % Set 3D camera angle
title('Digital Speech Processing');
xlabel('frequency (Hz)'); ylabel('time (s)'); zlabel('PSD');

for i=1:8                                              % Find Freq Components
     q=find(Power(1:FFT_length/2,i)==max(Power(1:FFT_length/2,i)));
     Power(q-5:q+5,i)=0;
     components(1,i)=f(q);
     q=find(Power(1:FFT_length/2,i)==max(Power(1:FFT_length/2,i)));
     components(2,i)=f(q);

                                                       % Decide Vowel
     if or(and(abs(components(1,i)-70)<5,abs(components(2,i)-110)<5),...
           and(abs(components(1,i)-110)<5,abs(components(2,i)-70)<5));
        disp('A');
    elseif or(and(abs(components(1,i)-50)<5,abs(components(2,i)-180)<5),...
           and(abs(components(1,i)-180)<5,abs(components(2,i)-50)<5));
        disp('E');
    elseif or(and(abs(components(1,i)-40)<5,abs(components(2,i)-200)<5),...
        and(abs(components(1,i)-200)<5,abs(components(2,i)-40)<5));
        disp('I');
    elseif or(and(abs(components(1,i)-60)<5,abs(components(2,i)-80)<5),...
        and(abs(components(1,i)-80)<5,abs(components(2,i)-60)<5));
        disp('O');
    elseif or(and(abs(components(1,i)-30)<5,abs(components(2,i)-60)<5),...
        and(abs(components(1,i)-60)<5,abs(components(2,i)-30)<5));
        disp('U');
    end

    if i==1                                            % Decide Time Slot
```

```
        disp(' in 0 to 1 second time slot');
    elseif i==2
       disp(' in 1 to 2 second time slot');
    elseif i==3
        disp(' in 2 to 3 second time slot');
    elseif i==4
        disp(' in 3 to 4 second time slot');
    elseif i==5
        disp(' in 4 to 5 second time slot');
    elseif i==6
        disp(' in 5 to 6 second time slot');
    elseif i==7
        disp(' in 6 to 7 second time slot');
    elseif i==8
        disp(' in 7 to 8 second time slot');
    end
end
```

Problem 3

```
% EE5322 - Intelligent Control Systems
% HW2 - RLS and DFT Analyses
% David (Jerrod) English
% 30 January 2014

clear all; load('Prob3.mat');                          % Import Data
k=Prob3(:,1); data=Prob3(:,2);

FFT_length=2^10;                                       % Set FFT length
Ts=0.001;                                              % Sampling period

w=2*pi/(FFT_length)*([1:FFT_length]-1);                % Frequency axis
f=w./(2*pi*Ts);
fhalf=f(1:length(f)/2);

window=(length(data)-1)/12;                            % 1/2s window


for n=1:length(data)                                   % Windowed FFT's

    if n-(window-1)<1
        dft(:,n)=fft(data(1:n),FFT_length);
    else
        dft(:,n)=fft(data(n-(window-1):n),FFT_length);
    end

    Power(:,n)=dft(:,n).*conj(dft(:,n))/FFT_length;


end

mesh(fhalf',k*Ts,Power(1:FFT_length/2,:)');
view(15,52);                                           % Set 3D camera angle
title('Machinery Monitoring');
xlabel('frequency (Hz)'); ylabel('time (s)'); zlabel('PSD');

anomoly1=find(Power(284,:)>10);                % Find Pinion Gear Deg Time
t1=k(anomoly1(1))*Ts;

anomoly2=find(Power(206,:)>200);               % Find Gear Tooth Fail Time
t2=k(anomoly2(1))*Ts;

display('Pinion gear degradation at approximately');
t1
display('seconds.');
display('Gear tooth failure at approximately');
t2
display('seconds.');
```