LAB ASSIGNMENT 3

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Group Number: 37

1.Aim and Scope:

Here we study the structure of simple dynamic system which is approximated as single degree of freedom(SDOF) system

We use equations of motions for this system to measure the force and the acceleration under random excitation. The frequency response functions transfer functions and spectral densities are calculated from obtained data

We used two sensors impedance sensor and accelerometer sensors at input and output and connect it to channel 0 and channel 1 of the data acquisition unit respectively.

2. Experimental setup:

1) Cantilever Beam: It is an element of rigid structure, the testrig consists of a mass is connected at the end of the beam as shown in fig1

2) Accelerometer: It is a sensor which used to sense the vibration and cable to connect the channel

3) Force transducer: This transducer is used to convert any energy to force

4) National Instrument device: It is used to acquire data from channels

5) NI USB-9612 Shaker: It is used to provide vibrations.

6) Stinger: It is used to transfer vibrations to SDOF system

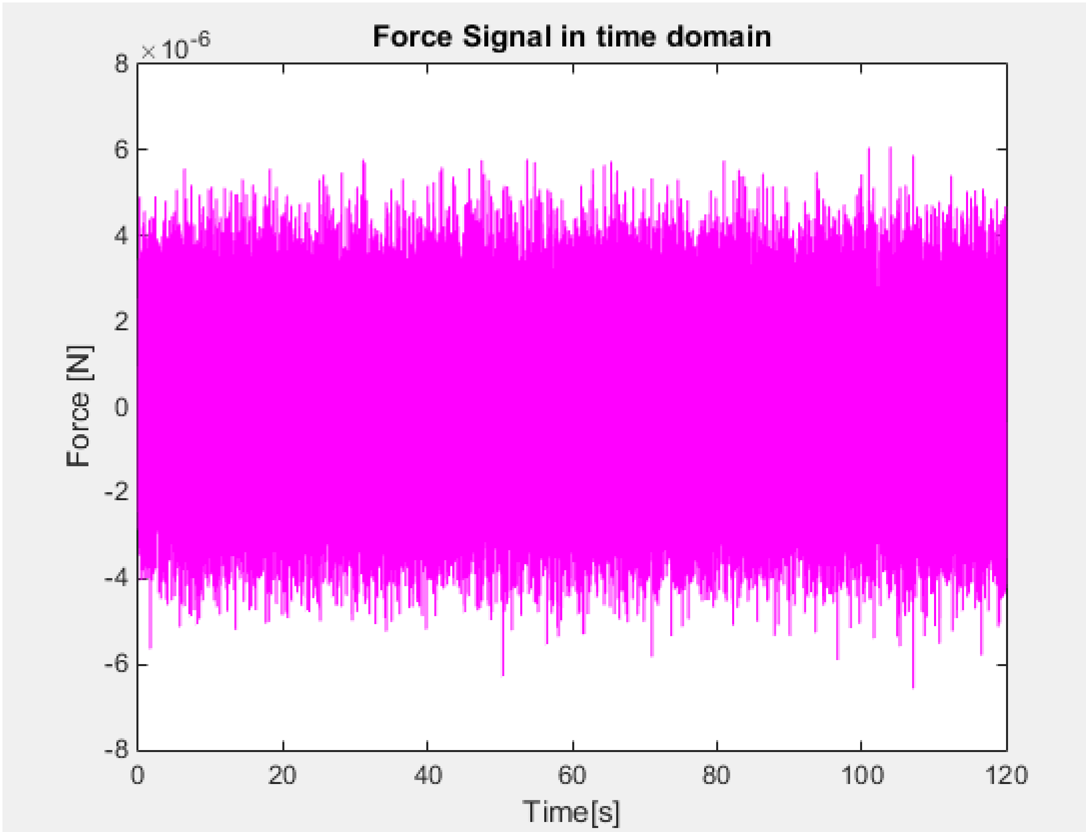
7) Signal Generator & amplifier: signal generator is used to generate signal and amplifier to amplify the given signal

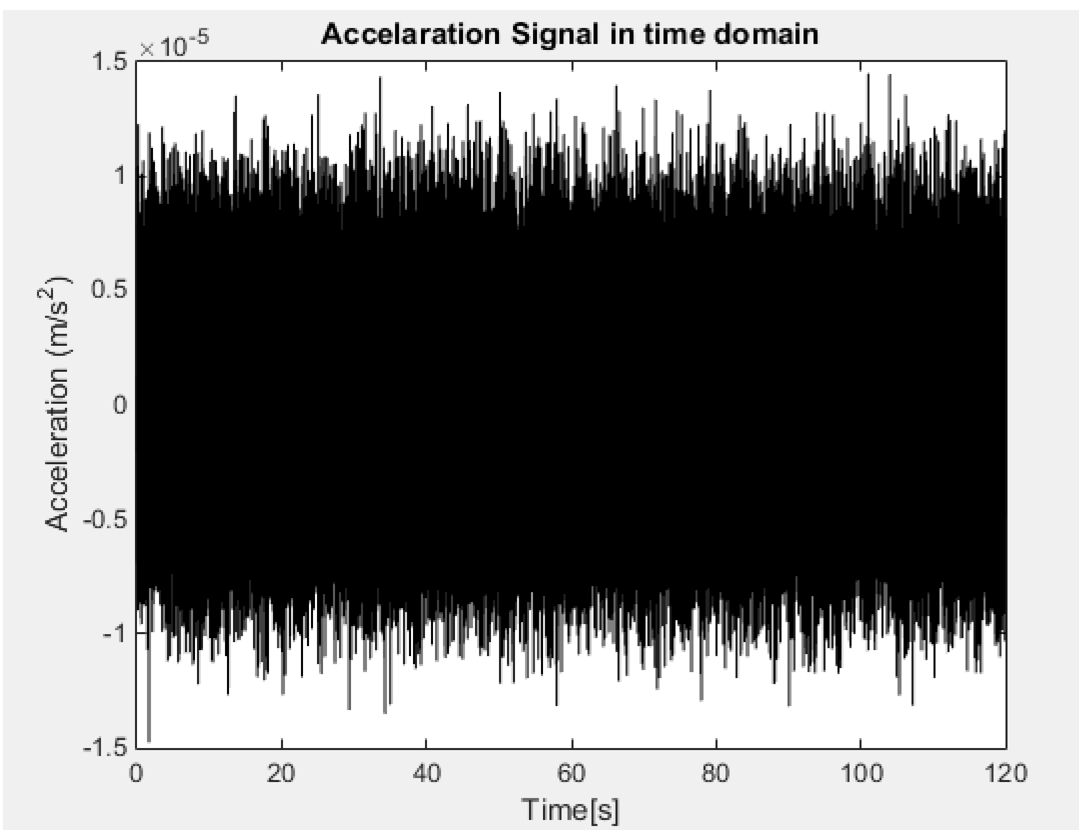
Figure 1. *The experimental setup*

3.Detailed Calculations and Results:

3.1 Task 1: Experimental Data.

In this task we use sensitivity to calculate force [N] and the acceleration [m/s^2] from voltage signals, we plot acceleration [m/s^2] and force in time domain


Force Signal in time domain
× 10^-6
8
6
4
2
0
-2
-4
-6
-8
Force [N]
0
20
40
60
80
100
120
Time[s]


Accelaration Signal in time domain
× 10^-5
1.5
1
0.5
0
-0.5
-1
-1.5
Acceleration (m/s^2)
0
20
40
60
80
100
120
Time[s]

3.2 Task 2: APDF (Amplitude Probability and Density Function).

In this task we calculate one of the property of the system called Amplitude Probability and Density Function for force & acceleration signals (two graphs), we plot the result together with a theoretical normal distribution in each case.

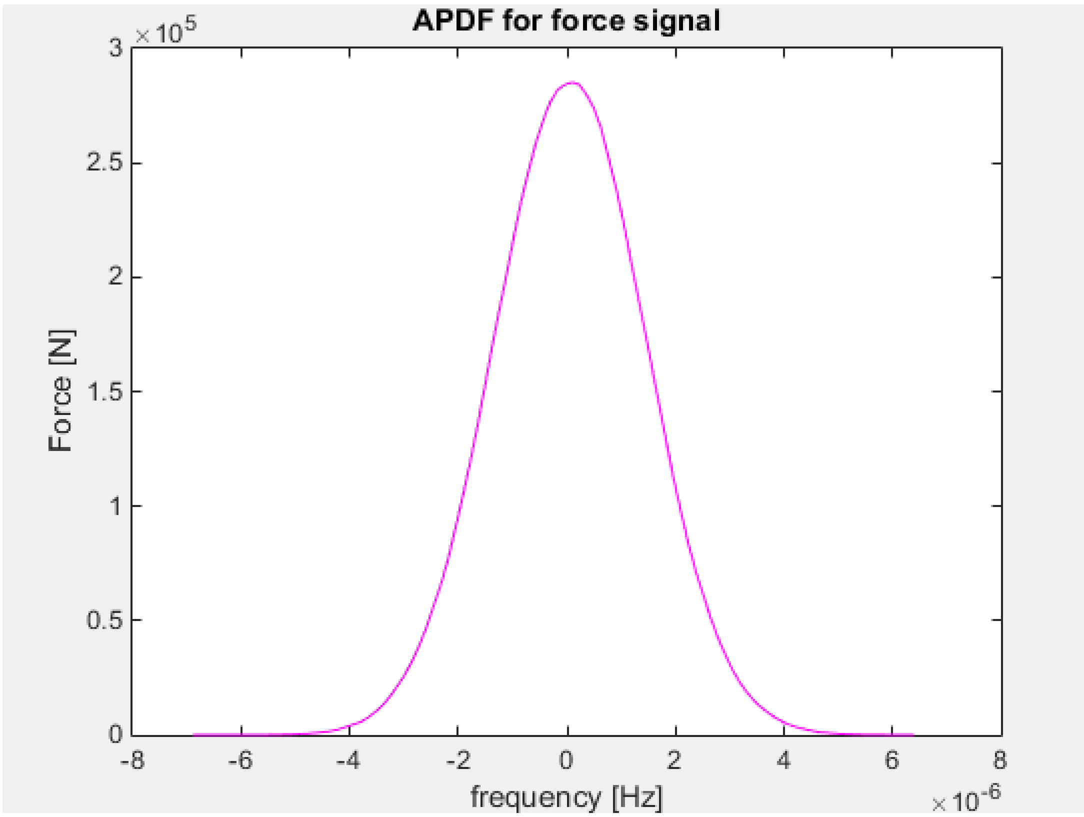


Figure-1

Figure 1 is a APDF for force signal and figure 2 is APDF for acceleration signal

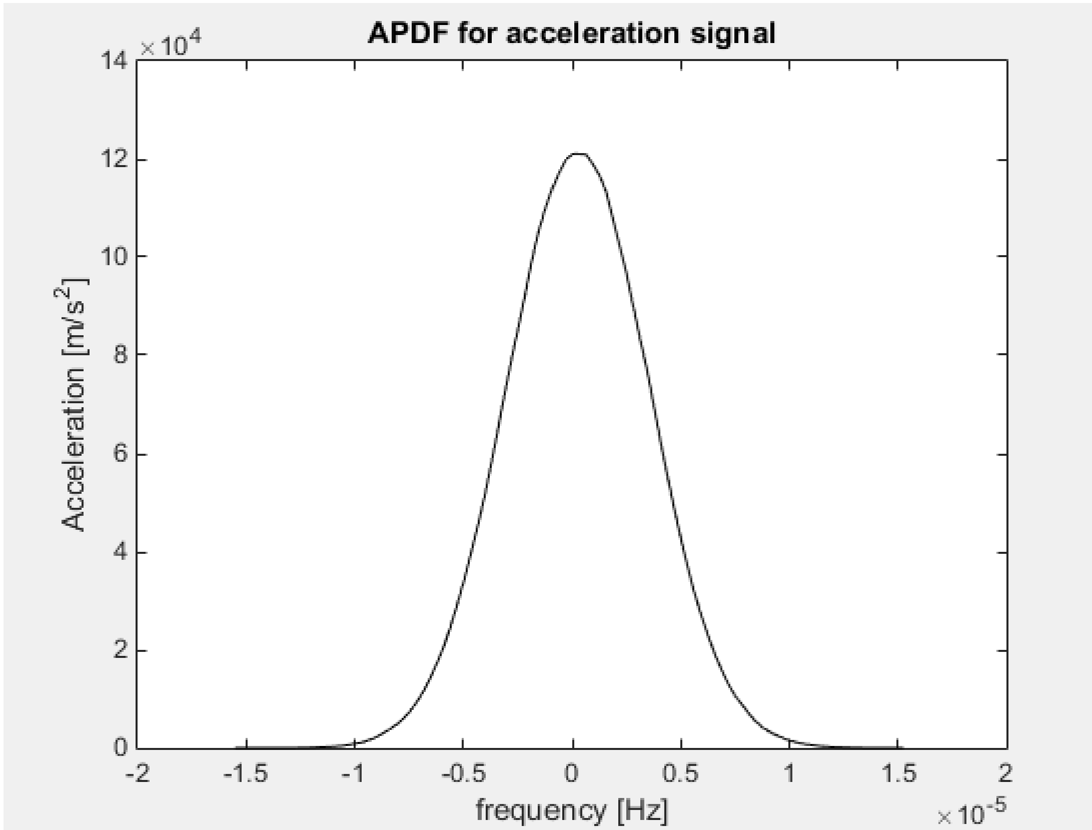


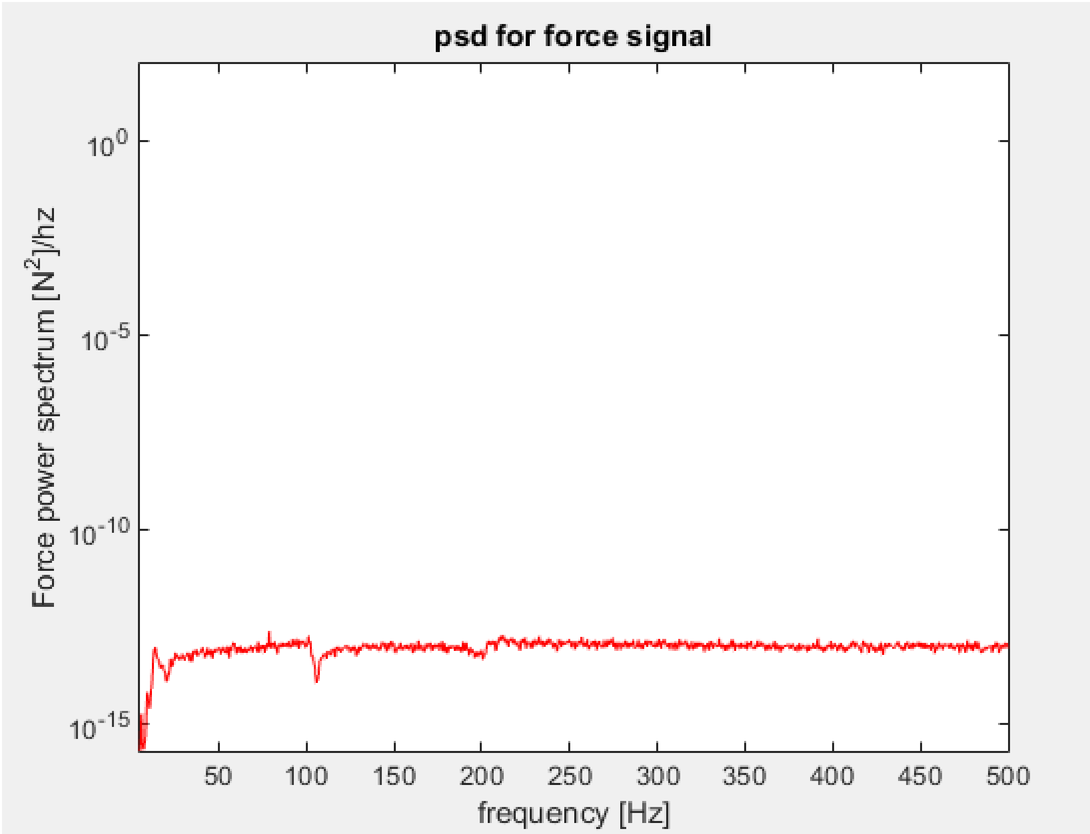
Figure -2

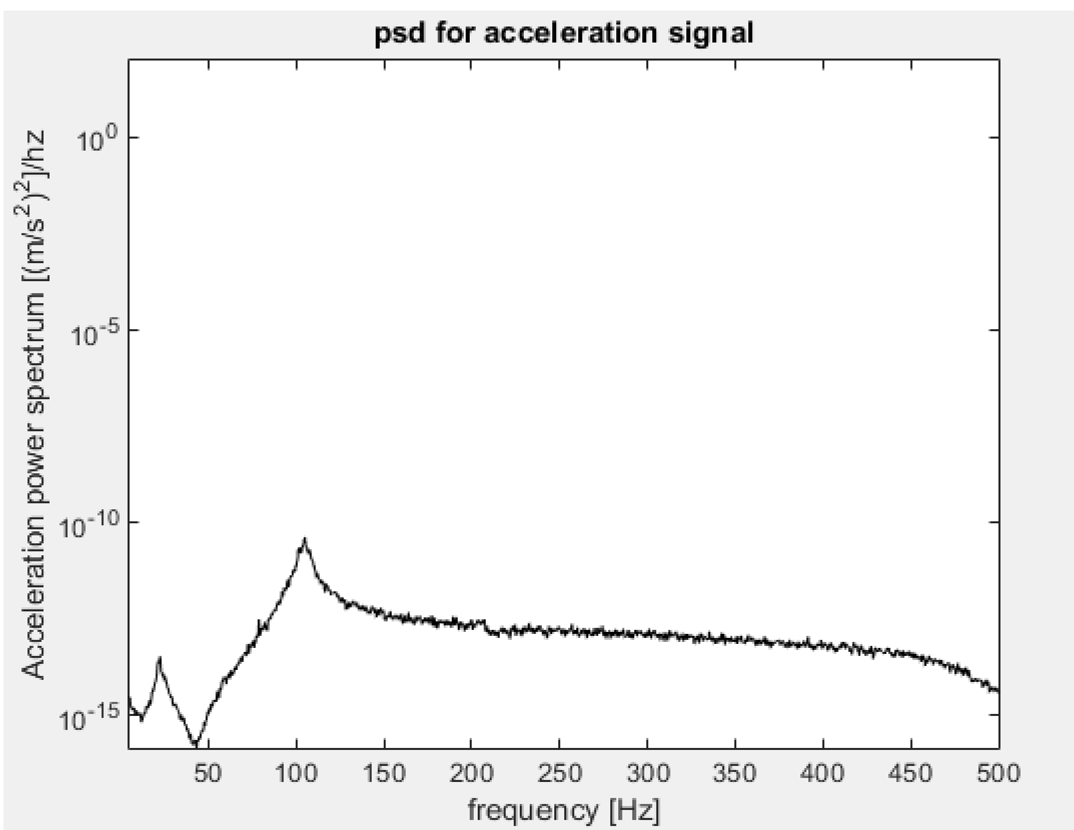
3.3 Task 3: Auto Spectral Densities.

In this task we will calculate power spectral densities of force and acceleration signal using 50% overlap and Hanning window,

Given that the frequency increment(df) should not be larger than the df shouldn't be larger than 0.2

We plotted power spectral densities for both signal force and acceleration between 5-500Hz as below.


psd for force signal
Force power spectrum [N2]/hz
10^0
10^-5
10^-10
10^-15
50
100
150
200
250
300
350
400
450
500
frequency [Hz]

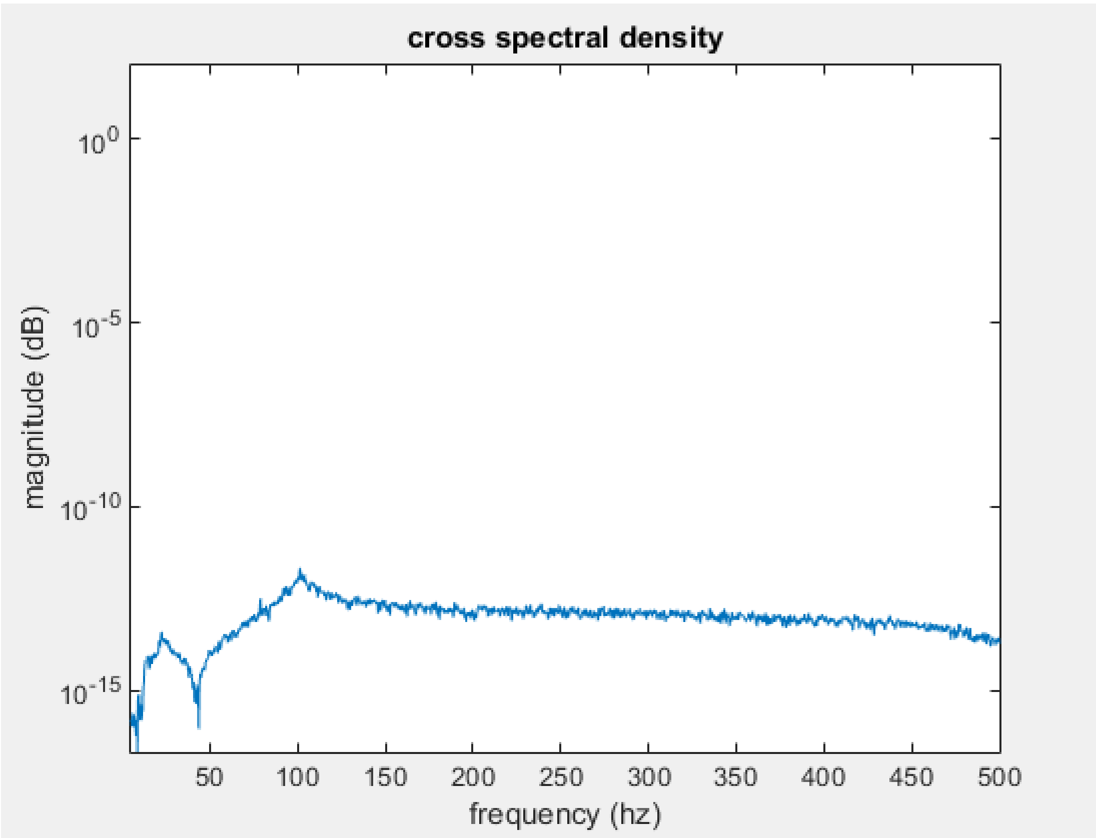

psd for acceleration signal
Acceleration power spectrum [(m/s2)2]/hz
10^0
10^-5
10^-10
10^-15
50
100
150
200
250
300
350
400
450
500
frequency [Hz]

3.4 Task 4: Cross Spectral Densities.

In this task we will calculate Cross spectral densities of force and acceleration signal using 50% overlap and Hanning window.

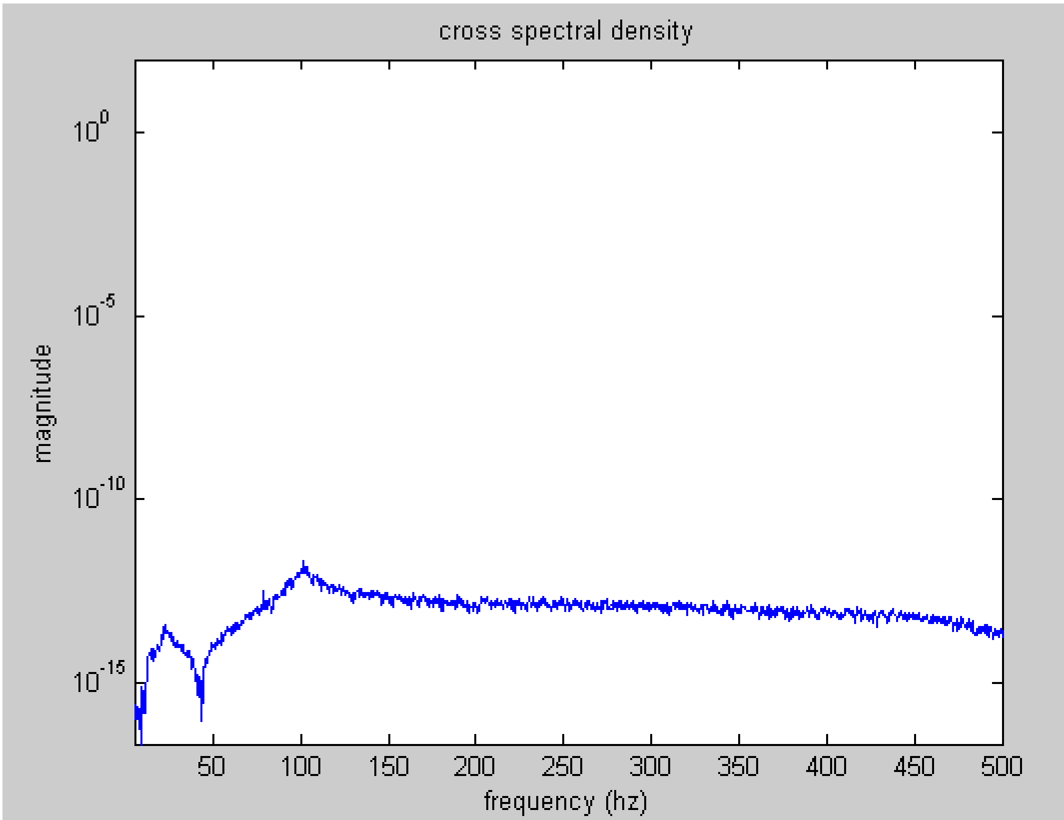
We plotted Cross spectral densities between both signal force and acceleration between 5-500Hz as below.

Cross power spectral density is same as power spectrum density but it uses cross correlation so you can find the power shared by a given frequency for the two signals using its squared module and the phase shift between the two signals at that frequency using its argument



3.5 Task 5: Frequency Response Functions.

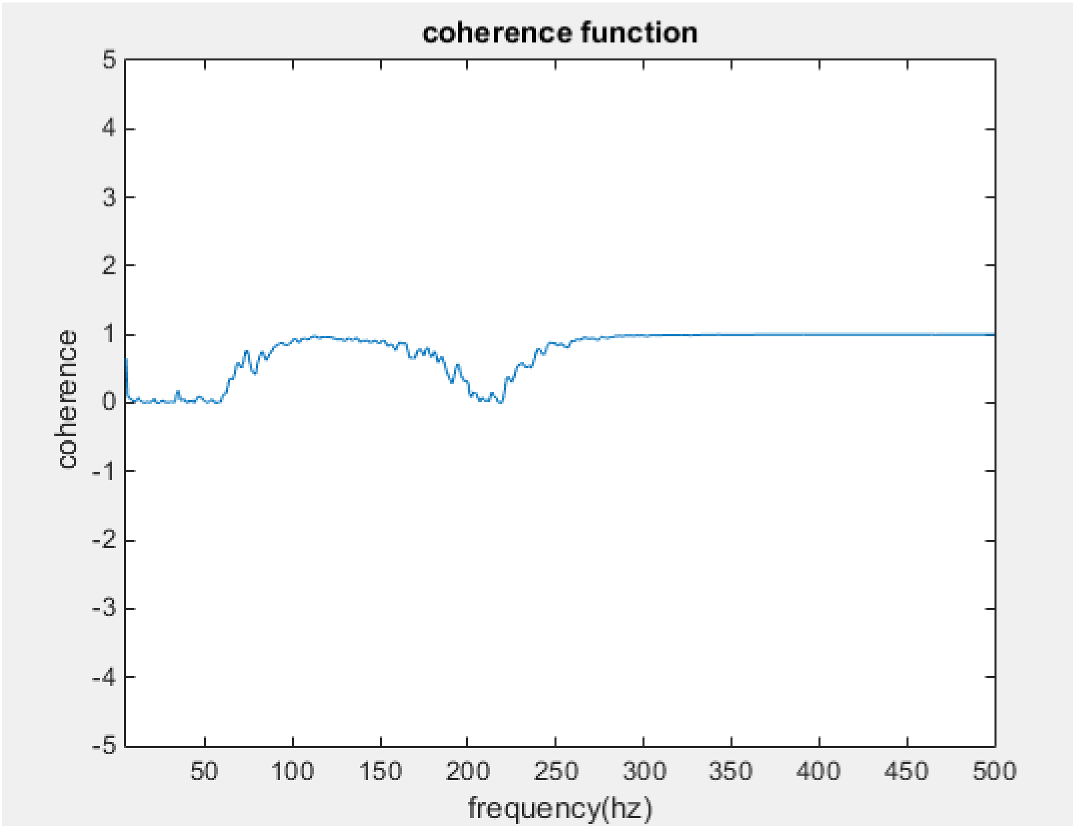
In this task we calculate frequency response function between force and acceleration using first H_1 estimator and then H_2 estimator and we plot both the graphs in a figure between the frequency range 5-500Hz.



3.6 Task 6: Coherence Functions.

In this Task we calculate the coherence function and plot it in a figure between frequency range 5-500Hz.

In coherence function when two signals (accelerance and force signals) are uncorrelated the sample coherence converges to 0. The coherence is the real function between 0 & 1 which gives the measure of correlation between two signals over given frequency range



3.7 Task 7: Comparison of Frequency Response Function.

When we compare frequency response function in the task 5 with the transfer functions of the assignment 1. we observe that the large part of the response of transfer function in the impulse hammer test is obtained around the resonant frequency of the impulse hammer signal.

4.Conculsion:

From this experiment we understand the structure of system which is approximated as single degree of freedom system. We measured the force and acceleration under random excitation we calculated the spectral densities and transfer function in the above tasks.

In task 1 we calculated Force and acceleration signals from voltage signals and they are plotted in time domain

In task 2 we calculated the Amplitude Probability Density Function for the force and acceleration signals and plotted the result together with theoretical normal distribution

In task 3 we calculated power spectral densities for force and acceleration signals using 50% overlap and hanning window and plotted them in frequency domain

In task 4 we calculated cross spectral densities between force and acceleration signals using 50% overlap and hanning window and plotted them in frequency domain

In task 5 we calculated frequency response functions between force and acceleration signals using H_1 & H_2 estimators and plotted them in frequency domain.

In task 6 we calculated coherence function and plotted in the frequency range.

5.Refernces.

[1]. Noise and vibration analysis: signal analysis and experimental procedures 2010/2011 written by Anders Brandt.

[2]. Math works.

Appendix:

Task 1:

```
clc;
clear all;
close all;
load('trail1lab3.mat');
output=data(:,2);
input=data(:,1);
accel=output./5.1*10^-3;
frc=input./22.4*10^-3;
figure
plot(time,frc,'m');
xlabel('Time[s]');
ylabel('Force [N]');
title('Force Signal in time domain');
figure
plot(time,accel,'k');
xlabel('Time[s]');
ylabel('Acceleration (m/s^2)');
title('Accelaration Signal in time domain');
```

Task 2:

```
[f1,x1]=ksdensity(frc);
[f2,x2]=ksdensity(accel);
figure
plot(x1,f1,'m')
xlabel('frequency [Hz]');
ylabel('Force [N]');
title('APDF for force signal')
figure
plot(x2,f2,'k')
xlabel('frequency [Hz]');
ylabel('Acceleration [m/s^2]');
title('APDF for acceleration signal')
```

Task 3:

```
samplingfrequency=4166.6667;
df=0.2;
N=samplingfrequency/df;
K=[0:N-1]*0.2;
window1=hann(N);
P1=pwelch(frc,window1);
figure
semilogy(K(1:16385),P1,'r');
xlabel('frequency [Hz]');
ylabel('Force power spectrum [N^2]/hz');
title('psd for force signal')
axis([5 500 -10 10^2])
window2=hann(N);
P2=pwelch(accel,window2);
figure
semilogy(K(1:16385),P2,'k');
xlabel('frequency [Hz]');
ylabel('Acceleration power spectrum [(m/s^2)^2]/hz');
axis([5 500 -10 10^2])
title('psd for acceleration signal')
```

Task 4:

```
[Pxy,f]=cpsd(frc,accel,window1,samplingfrequency);
figure
semilogy(K(1:length(Pxy)),(abs(Pxy)));
xlabel('frequency (hz)')
ylabel('magnitude (dB)')
axis([5 500 -100 100])
title('cross spectral density')
```

Task 5:

```
[Pyx,f] = cpsd(accel,frc,window1,samplingfrequency);
h1 = Pyx./P1;
figure
```

```
semilogy(K(1:length(Pyx)),(abs(h1)),'m');
h2 = P2./Pxy;
hold on
semilogy(K(1:length(P2)),(abs(h2)),'g');
xlabel('frequency(hz)')
ylabel('magnitude in dB')
axis([5 500 -10 100])
title('frequency responce function')
```

Task 6:

```
[Cxy,F] = mscohere(accel,frc,window1,samplingfrequency);
plot(Cxy);
xlabel('frequency(hz)')
ylabel('coherence')
axis([5 500 -5 5])
title('coherence function')
```