Lab Assignment 3

Date: 2016-05-16
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1. Aim and Scope:

In this experiment we will study the structure approximated as the single degree of freedom system. With the equations of SDOF we can calculate force and acceleration under random excitation. With the given data as random signal we need to calculate frequency,PSD,transfer functions. In this experiment we have different tasks to be performed basing on the measurements obtained.

2. Experimental Setup:

In this experiment we will use cantilever beam, accelerometer and cable, amplifier, Force transducer and cable, Data acquisition unit, shaker, stinger, signal generator.
We will take the output response(accelerometer) values from the cantilever beam which has a mass attached to it

Figure 1. *The experimental setup*

Force transducer, accelerometer and shaker are connected to the experimental setup through a stinger. Force and the acceleration can be measured through Data acquisition unit

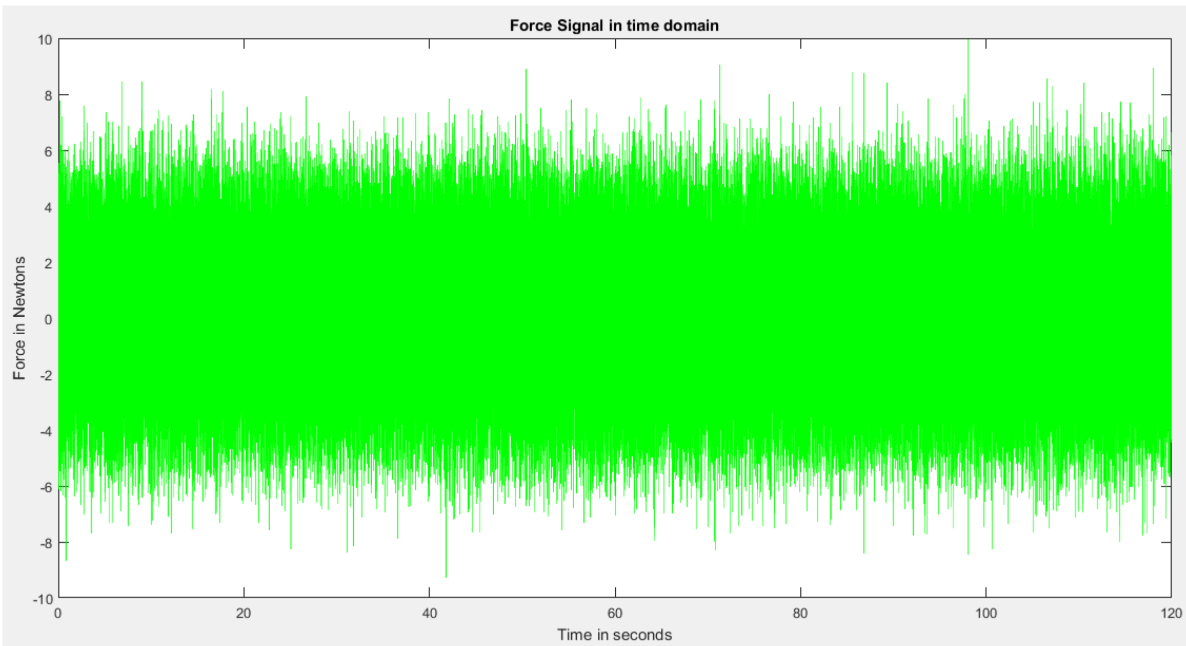
Figure 3. *The data acquisition unit*

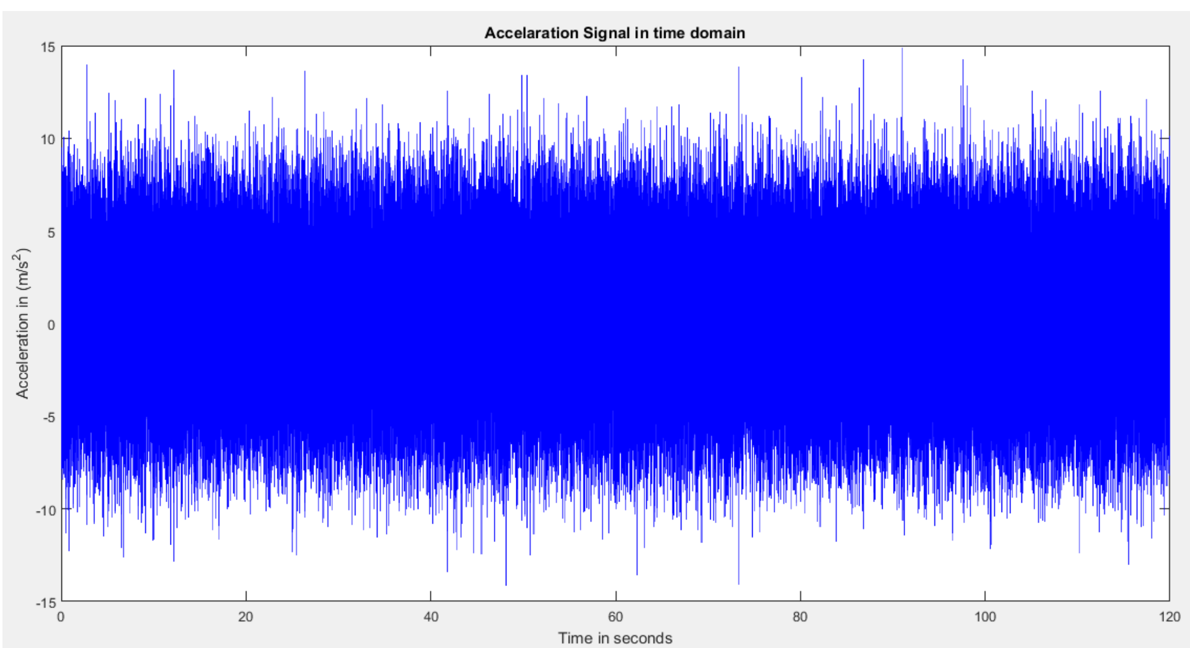
The data acquisition unit consists of different channels and we use three among them. Accelerometer cable is connected to the channel ai0 and Force transducer cable is connected to the channel ai1 of the data acquisition unit to measure the acceleration and force. After USB unit is connected to the computer. Signal generator is used to generate noise (white excitation signal) and it is sent to the amplifier. The syntax used is
Volt=addAnalogInputChannel('dev1' 'ai0' 'voltage');
Volt is the measured voltage signals first column of the acceleration signal and second column of the force signal.
Sampling frequency fs= 4000 and time is T= N/fs seconds
N- number of samples to collect
In this we need to wait for atleast 120 seconds to measure force and acceleration.

3. Detailed Calculations and Results

3.1 Task 1: Calculation of force and acceleration from the voltage signals using sensitivity and plot in time domain

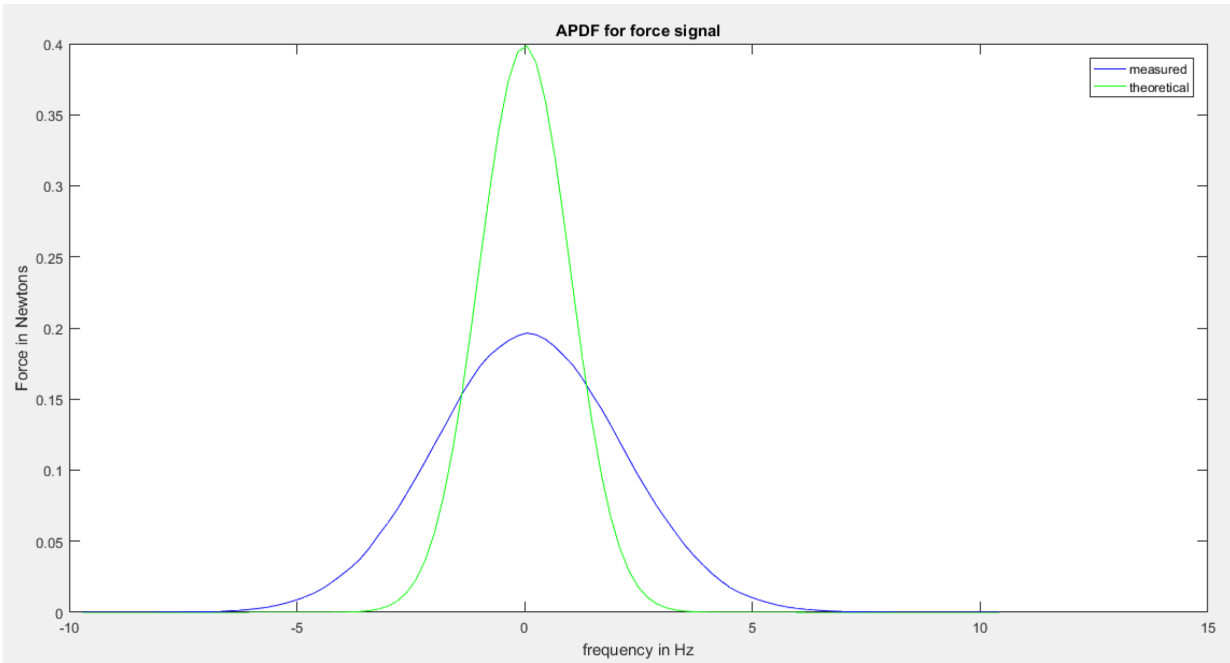
We are going to calculate the force and the acceleration using sensitivity from the obtained voltage signals and plot them in time domain

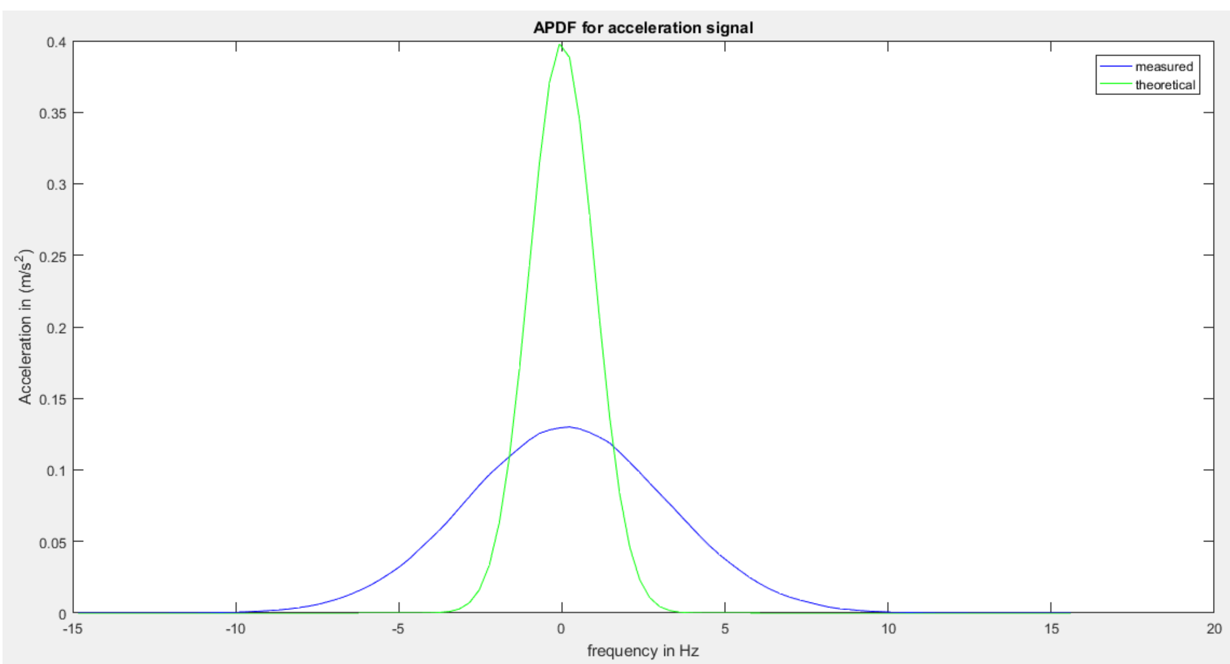




3.2 Task 2: Calculation of amplitude probability density function for both force and acceleration signals

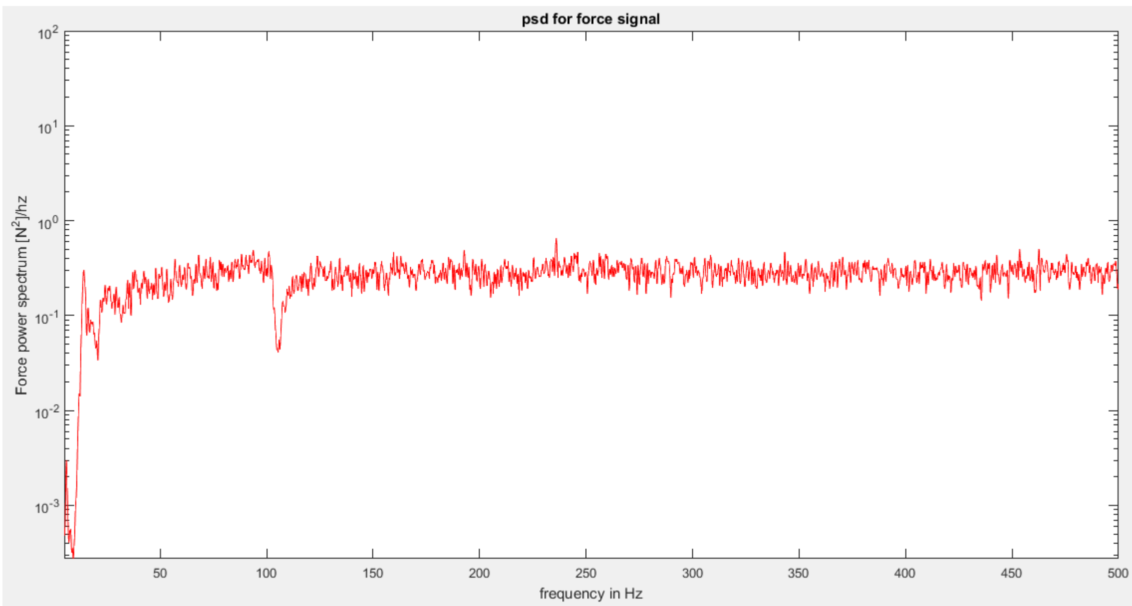
We are going to calculate the amplitude probability density function for both force and acceleration signals and plot them with a theoretical normal distribution.

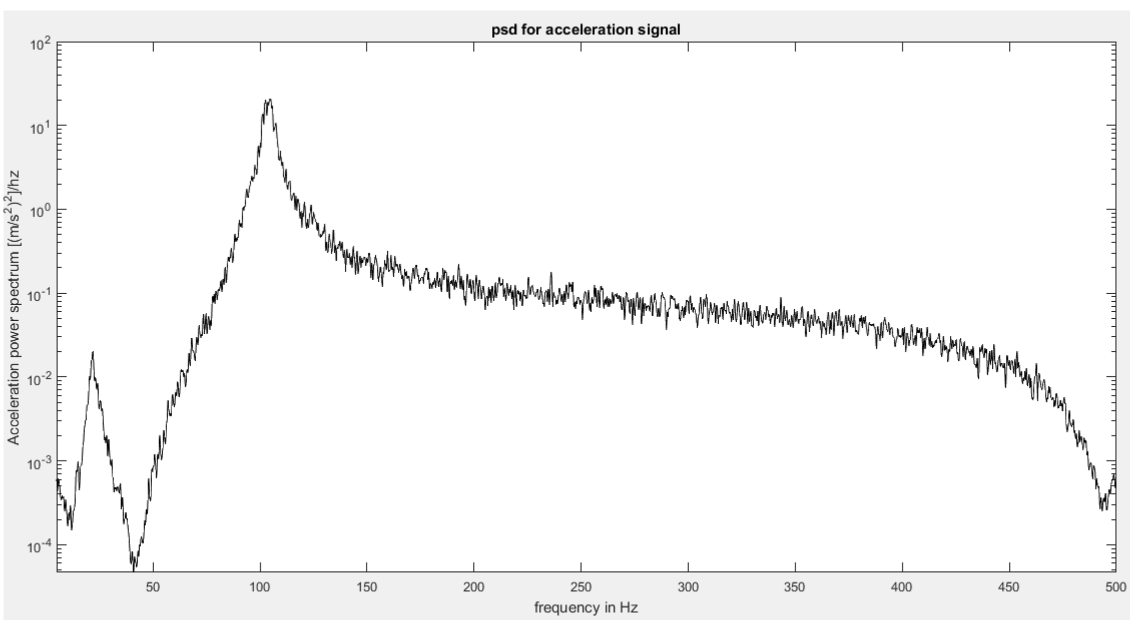




3.3 Task 3: Calculation of PSD of force and acceleration signals and plotting them

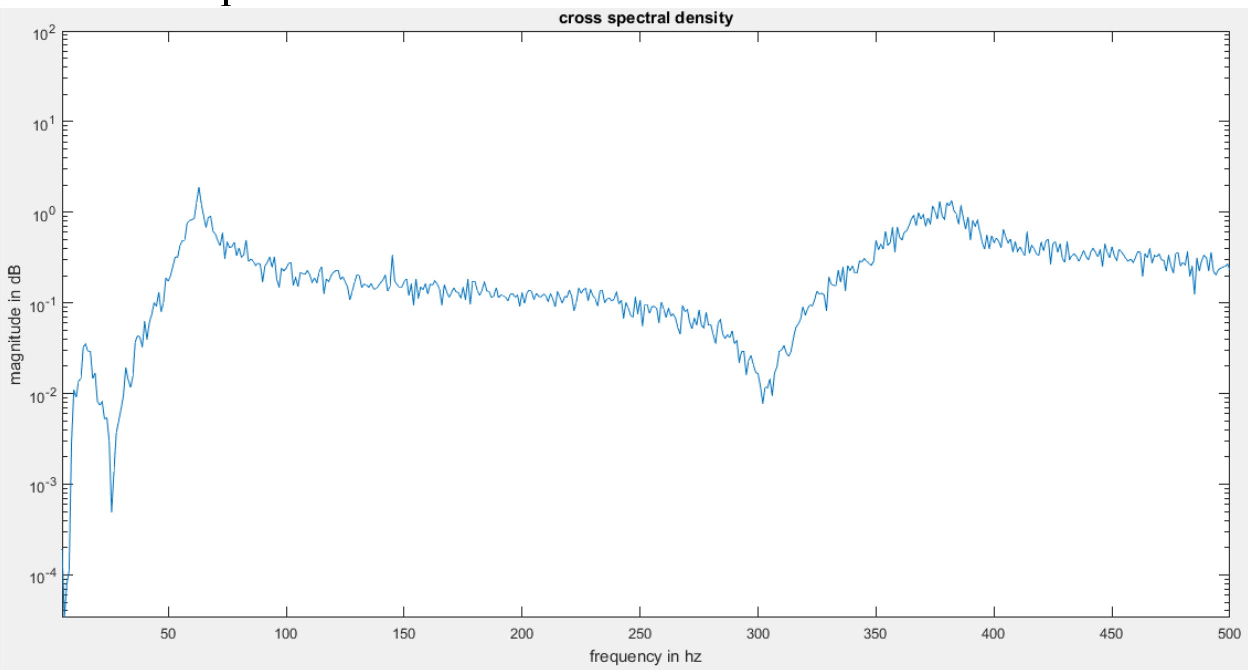
We are going to calculate the power spectral densities for both the force and acceleration signals using 50% overlap and a hanning window with given df =0.2 Hz and plot them in between 5 Hz to 500 Hz.





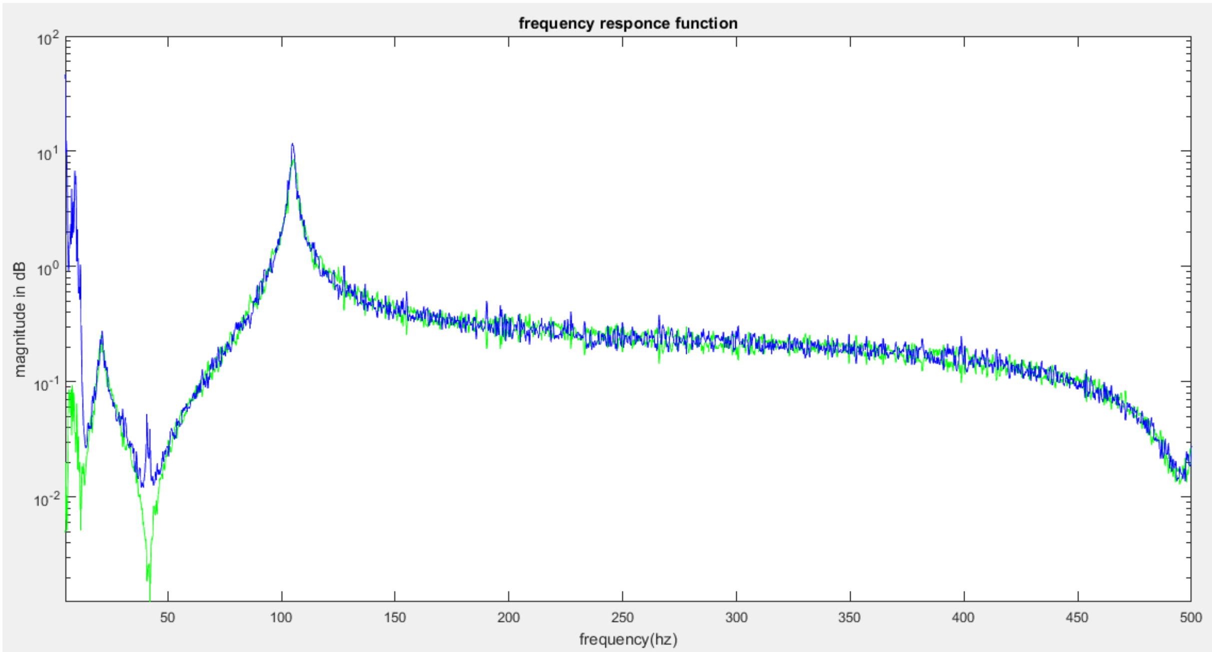
3.4 Task 4: Calculation of the cross spectral densities and plotting them

We are going to calculate the cross spectral densities between the force and acceleration signals using 50% overlap and a hanning window and plot CSD between 5 Hz to 500 Hz.



3.5 Task 5: Calculation of frequency response functions between force and acceleration using H1 and H2 estimator

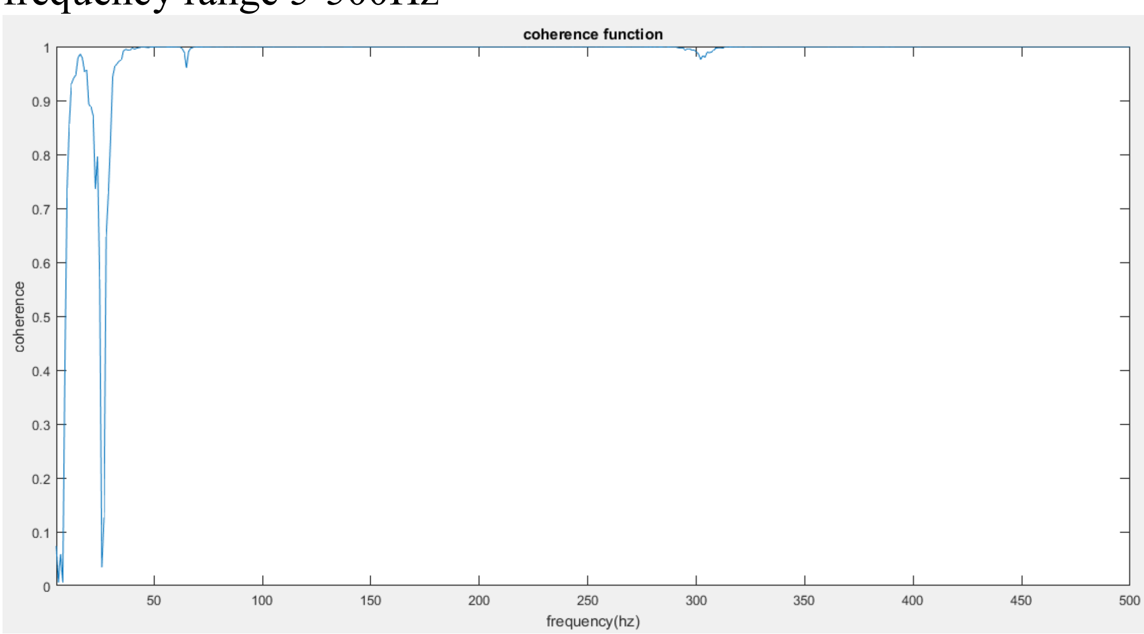
We are going to calculate the frequency response functions between the force and acceleration signals using H1- estimator and H2-estimator and plot them in the range 5Hz to 500Hz.



In frequency response function we can observe positive amplitude with the help of H1 and H2 estimator

3.6 Task 6: Calculation of coherence function and plot frequency in the range 5-500 Hz

We are going to calculate the coherence function and plot in the frequency range 5-500Hz



3.7 Task 7: Comparison

The frequency response function obtained in task 5 and transfer functions obtained in assignment-1 have the maximum amplitude at frequency range 90-100 Hz which are similar and proportional.

4. Conclusion

From this experiment we can conclude that, a single degree of freedom system is studied and the force and acceleration signals are calculated under random excitation with the help of voltage signals obtained. Amplitude probability density functions for both force and acceleration signals are calculated and plotted. After that power spectral densities for both force and acceleration signals are calculated and plotted. After calculating PSDs Cross spectral density between the force and acceleration signals are calculated with 50%overlap and using hanning window and plotted in the frequency range (50- 500)Hz . Frequency response functions between the force and acceleration signals are plotted using H1and H2 estimator and plotted. Coherence function is calculated and plotted in the frequency range (50-500)Hz . A necessary comparision in task-7 between assignment 1 and task-5 for frequency response

References

[1] Anders Brandt, Noise and vibration analysis, 2010/2011 ed.
[2] Internet Source (Mathworks).

Appendix:

Task 1

```
clc;          %clear command window
clear all;    %clear workspace
close all;    %closing figures
load('lab3.mat'); %loading recorded mat file
acceloutput=data(:,2); %output as accelerometer
forceinput=data(:,1);  %force as input
force=forceinput/0.0224;
```

```
accelerance=acceloutput/0.0102;
figure
plot(time,force,'g'); %plotting force in time domain
xlabel('Time in seconds');
ylabel('Force in Newtons');
title('Force Signal in time domain');
figure
plot(time,accelerance,'b'); %plotting accelerance in time domain
xlabel('Time in seconds');
ylabel('Acceleration in (m/s^2)');
title('Accelaration Signal in time domain')
```

Task 2

```
%%
[a1,b1]=ksdensity(force); %kernel density
[a2,b2]=ksdensity(accelerance);
norm=normpdf(b1,0,1);
norm1=normpdf(b2,0,1);
figure
plot(b1,a1,'b')   %plotting force
hold on;
plot(b1,norm,'g')
xlabel('frequency in Hz');
ylabel('Force in Newtons');
title('APDF for force signal')
legend('measured','theoretical')
figure
plot(b2,a2,'b')   %plotting accelerance
hold on;
plot(b2,norm1,'g')
xlabel('frequency in Hz');
ylabel('Acceleration in (m/s^2)');
title('APDF for acceleration signal')
legend('measured','theoretical')
```

Task 3

```
%%
sampling_fre=4000; %giving the sampling frequency
df=0.2;     %difference in frequency
N=sampling_fre/df;   %block size
f=[0:N-1]*df;
Noverlap=50;
acceloutput=data(:,2); %output as accelerometer
forceinput=data(:,1);  %force as input
%using hanning window since signal is random
P1=pwelch(force,hann(N),Noverlap); %using pwelch function,
figure
semilogy(f(1:length(P1)),P1,'r'); %plotting in semilogy
xlabel('frequency in Hz');
ylabel('Force power spectrum [N^2]/hz');
title('psd for force signal')
axis([5 500 -10^1 10^2])       %sets scaling for x-axis and y-axis
P2=pwelch(accelerance,hann(N),Noverlap);
```

```
figure
semilogy(f(1:length(P2)),P2,'k');
xlabel('frequency in Hz');
ylabel('Acceleration power spectrum [(m/s^2)^2]/hz');
axis([5 500 -10^1 10^2])
title('psd for acceleration signal')
```

Task 4

```
%%
[Pxy,f]=cpsd(force,accelerance,hann(N),Noverlap,sampling_fre);%cross
power spectral density as function
figure
semilogy((abs(Pxy)));  %plotting in semilogy graph
xlabel('frequency in hz')                %naming xlabel
ylabel('magnitude in dB')                %naming ylabel
axis([5 500 -10^2 10^2])             %sets scaling for x-axis and y-axis
title('cross spectral density')          %naming figure title
```

Task 5

```
%%
[Pyx,f] = cpsd(force,accelerance,hann(N),50); %cross power spectral
density as function
h1 = Pyx/P1;                                %obtaining magnitude
figure
semilogy((abs(h1)),'g');  %plotting in semilogy graph
h2 = P2/Pxy;
hold on
semilogy((abs(h2)),'b');
xlabel('frequency(hz)')
ylabel('magnitude in dB')
axis([5 500 -10^1 10^2])             %sets scaling for x-axis and y-axis
title('frequency responce function')
legend('force','acceleration')
```

Task 6

```
%%
[coherence,f]=mscohere(force,accelerance,hanning(N),Noverlap,sampling_f
re)                  %coherence to minimize error
figure
plot(coherence)
xlabel('frequency(hz)')
ylabel('coherence')
axis([5 500 0 1])                %sets scaling for x-axis and y-axis
title('coherence function')
```