Vibration Open-Ended Project

REPORT 2019

[Experimental Investigation of Torsional Oscillations of a Single Rotor with Viscous Damping using MEMS accelerometer of an Android Smartphones and MATLAB.] [1]

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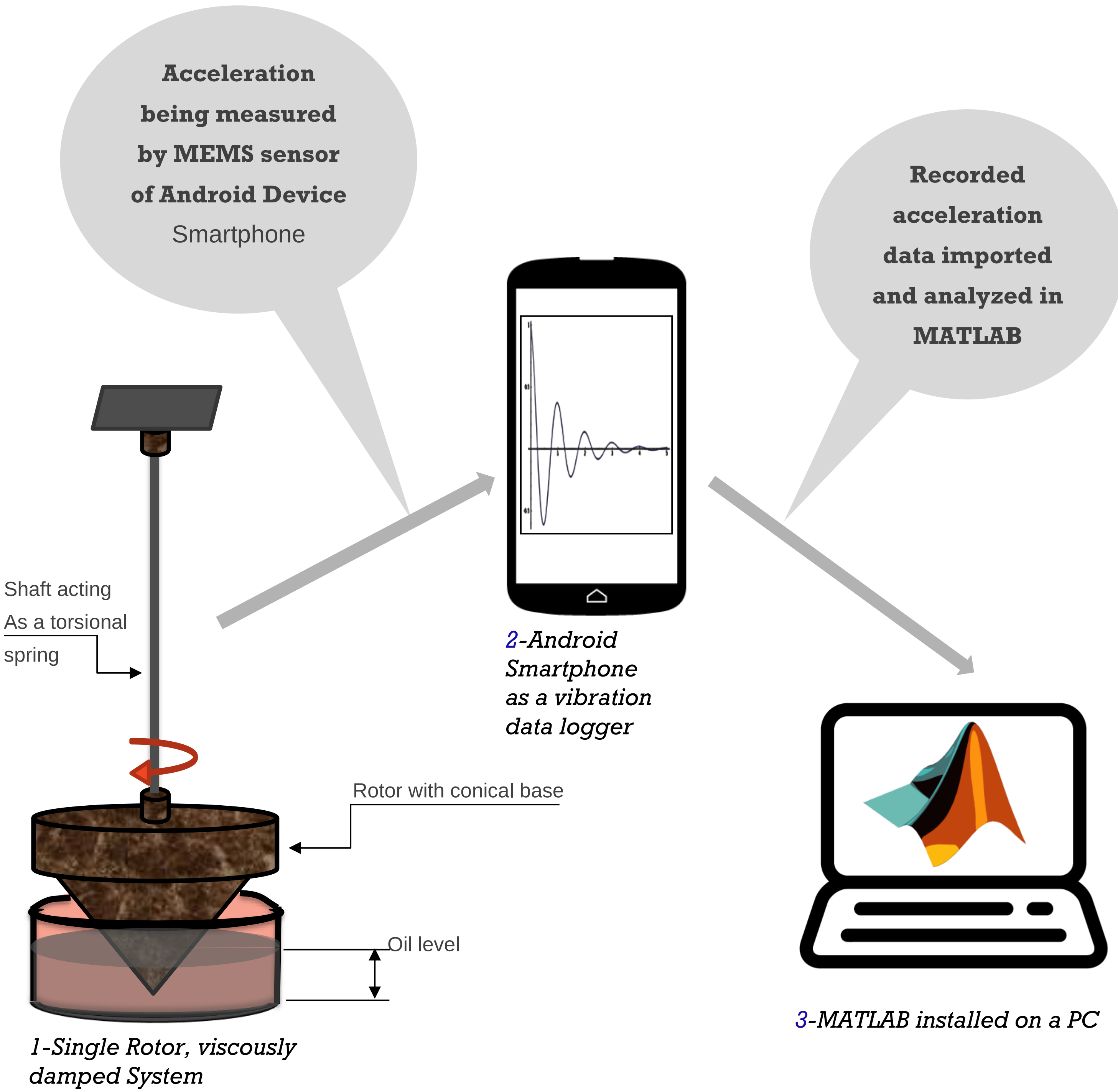
(1) Smartphone :Google Nexus 6p (2015) ; Sensor model: BMI160 ; Resolution:4.8mm/s^2

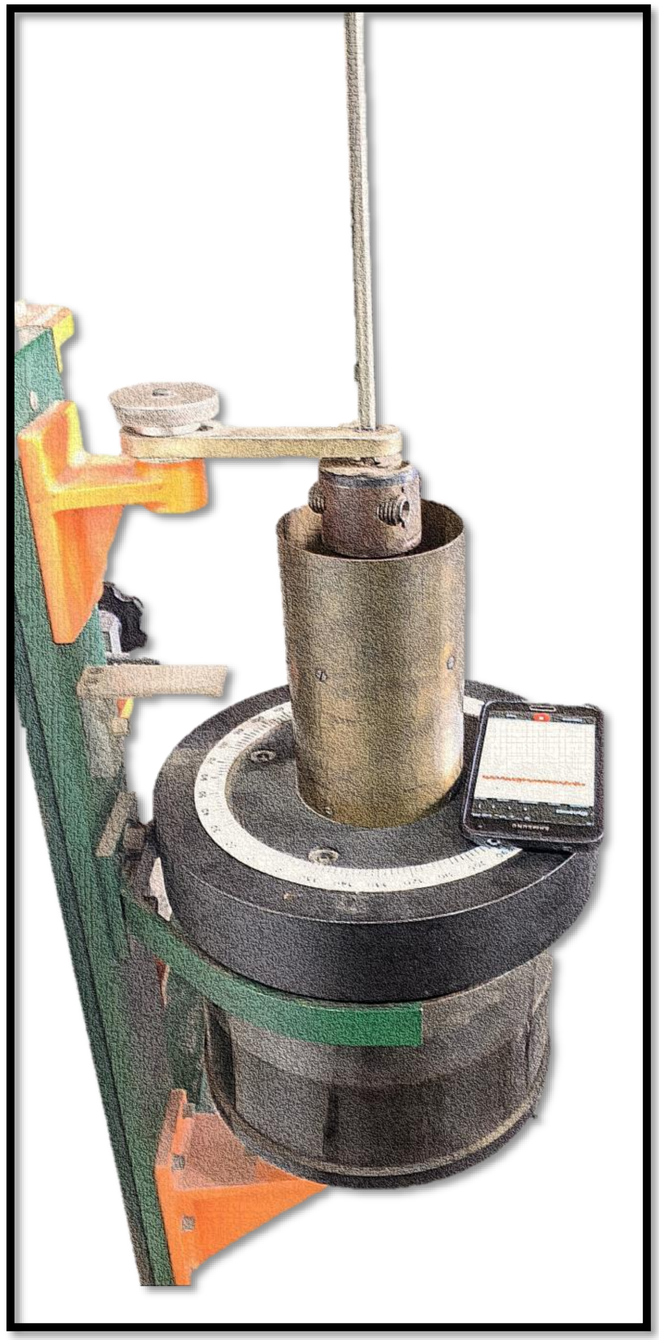
(2) Smartphone :Samsung Galaxy S5 (2015) ; Sensor model: MPU6500;Resolution:0.6mm/s^2



Introduction:

This work describes the potential of modern mobile devices for vibration analysis & system identification. It shows how smartphones can be used as a vibration data logger to record acceleration time-history of a vibrating system that can be analyzed later with a well-developed tool like Tom Irvine's vibrationdata MATLAB GUI[i] on MATLAB. Moreover, due to improved computational performance & visual capabilities on recent smartphones, the data being logged can be processed using FFT algorithm and monitored simultaneously using some open-source apps like “iDynamics”[ii] available at Google Play. Since MEMS accelerometer used in mobile phones are low-power and have relatively higher noise ratios compared to that of industrial grade MEMS accelerometers (Adxl100x), use of Butterworth filter of higher order can give satisfactory results .

Experimental Setup:

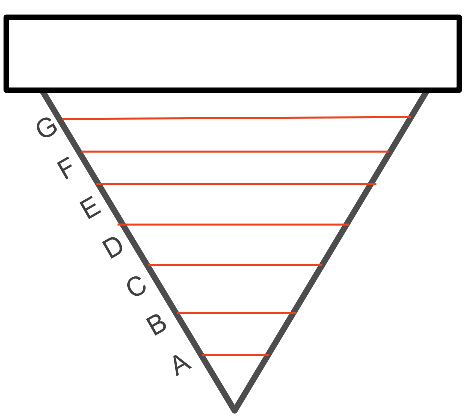


The setup includes:

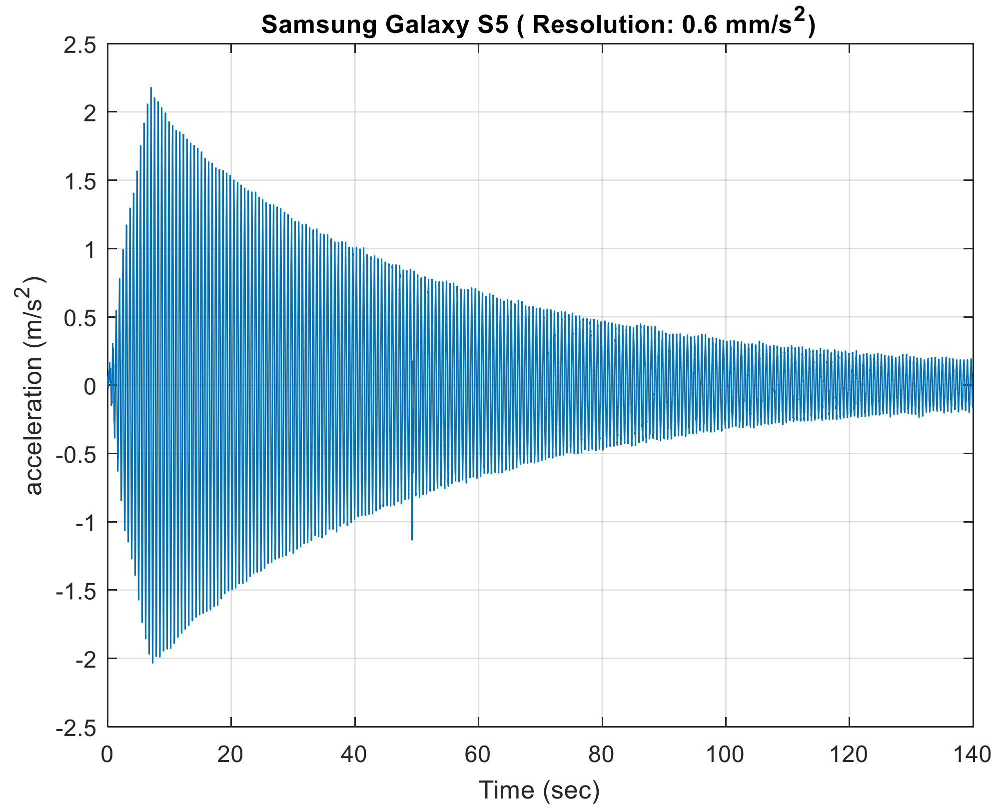
- Single Rotor with Viscous damping apparatus.
- Android Smartphone.
- A PC with MATLAB pre-installed.
- “Vibrationdata MATLAB GUI” by Tom Irvine.

The conical bottom of the rotor has the following marks

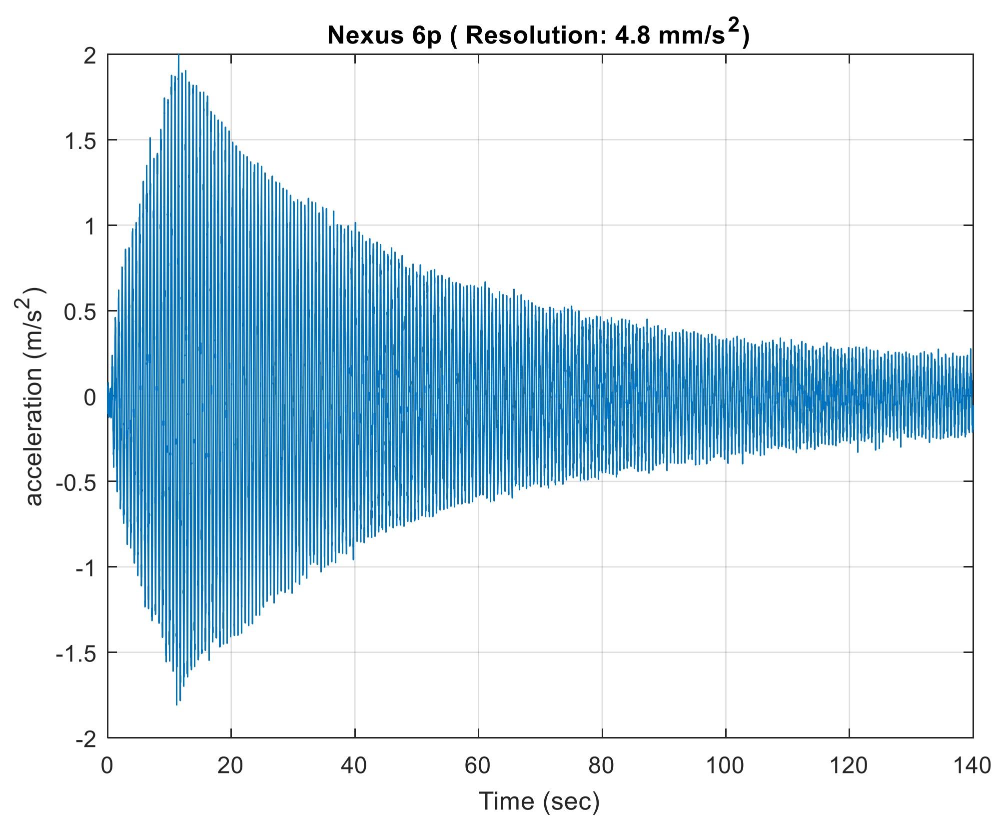
Mark Name`	Distance from the bottom(mm)	Radius(mm)
A	12.5	12.5
B	25.0	25.0
C	37.5	37.5
D	50.0	50.0
E	62.5	62.5
F	75.0	75.0
G	87.5	87.5



Comparison of Accelerometer Data of Two Smartphones



Galaxy S5 sensor draw more power from battery (0.25 mA) but offers a good resolution(0.6mm/s^2) Therefore more reliable for vibration measurements.



Nexus 6p sensor draw less power from battery (0.001 mA) but offers an average resolution(4.8mm/s^2) The data can still give satisfactory results after applying Butterworth filter.

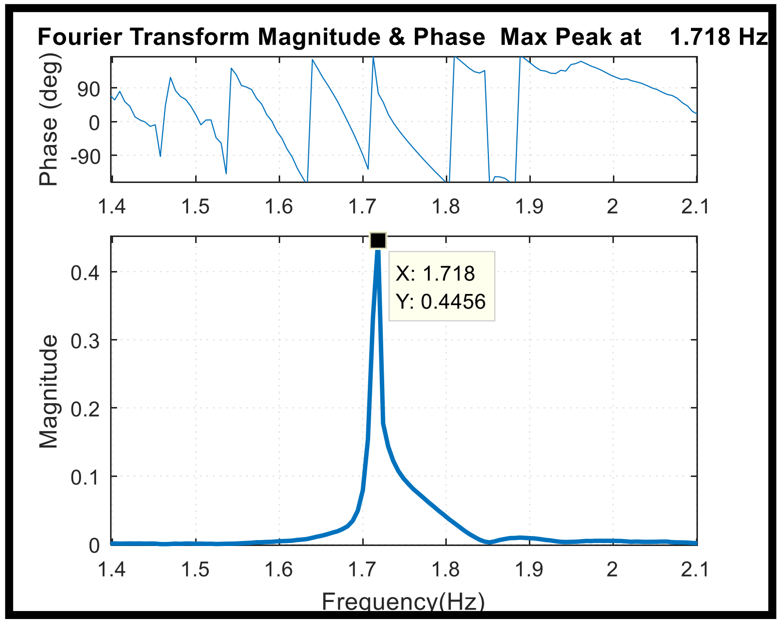
Comparison of Unfiltered & Filtered Data:

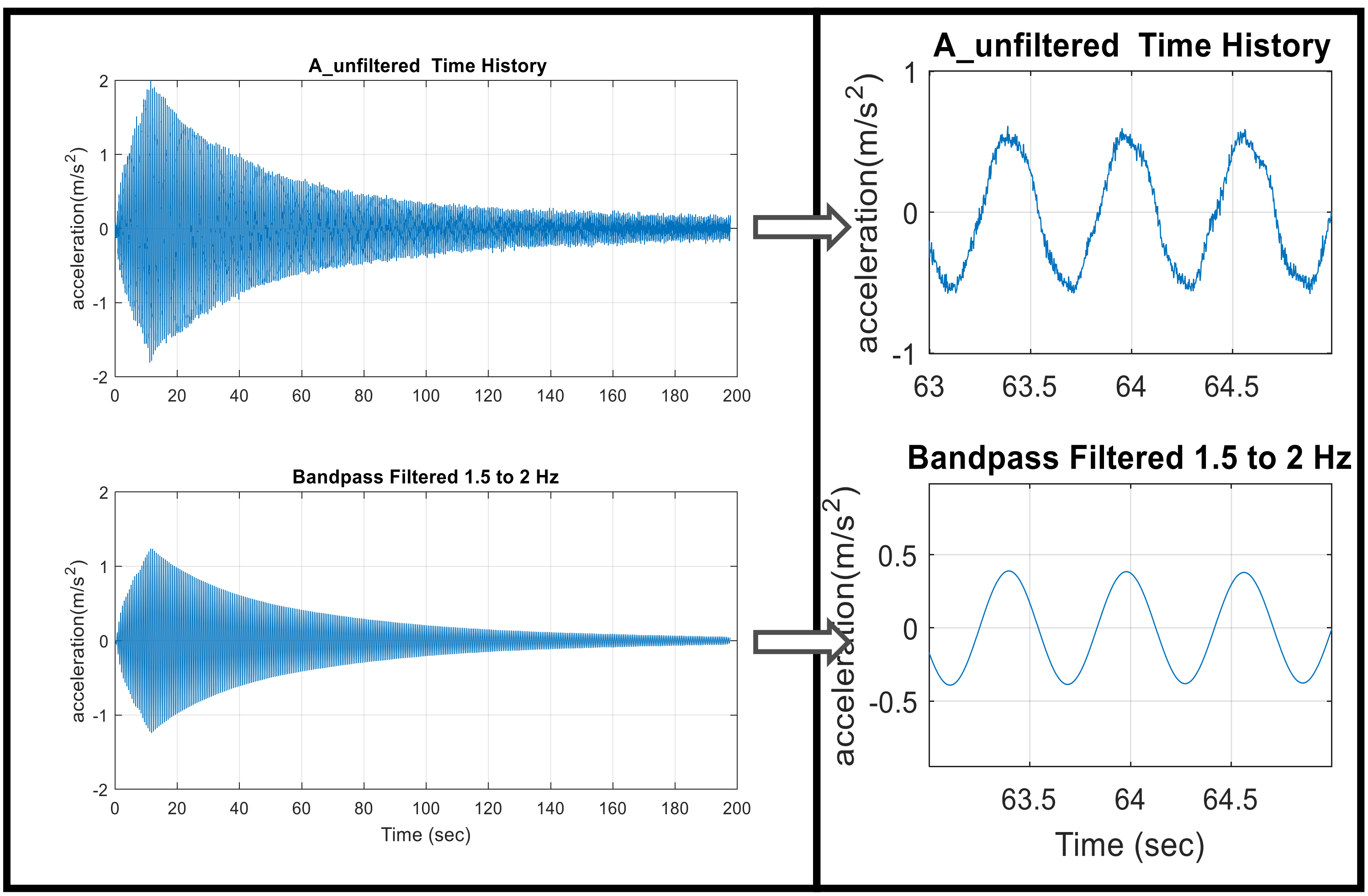
Here is a Comparison of Unfiltered accelerometer data which was taken when the oil in the oil sump is at mark **A**.

Since we are going to use Butterworth's Bandpass[iii] filter, we must first figure out the damped natural frequency of our underdamped system which can be found by doing an FFT of measured data.

FFT of our data shows a peak at **1.718Hz**

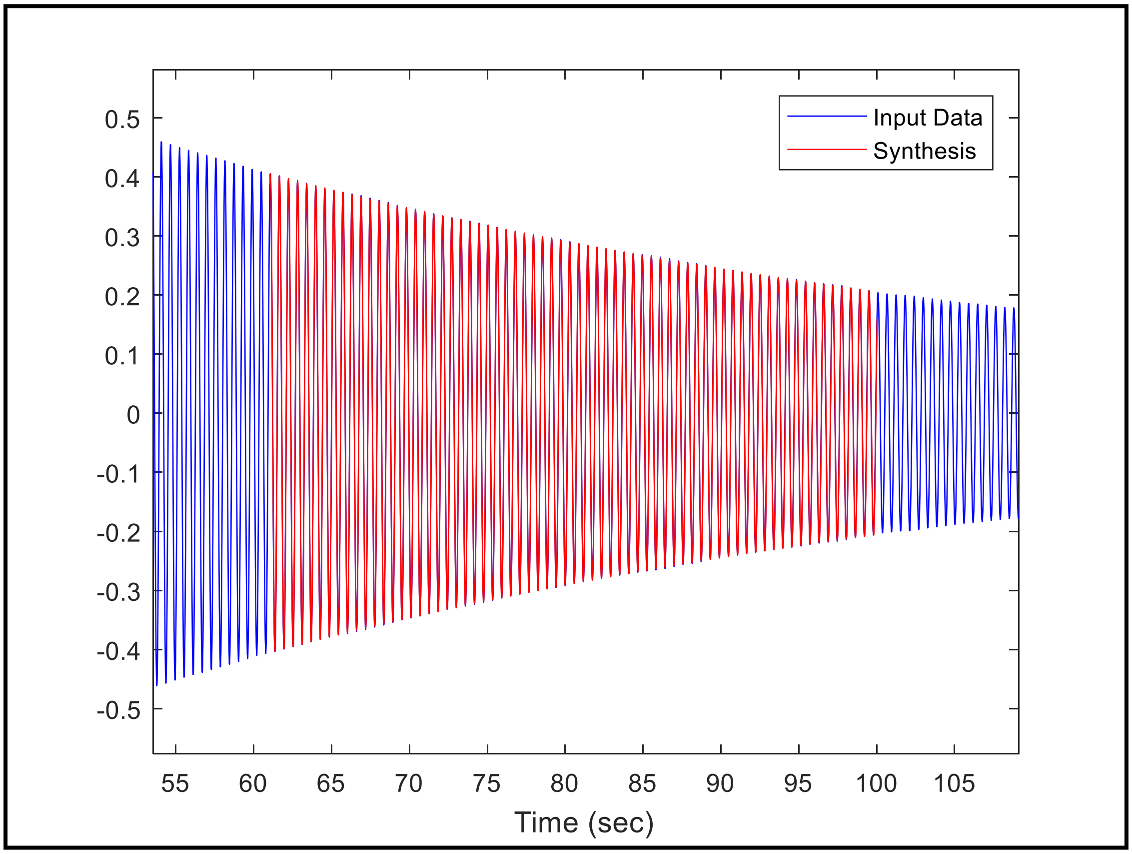
We can now apply a 6^{th} order band pass filter between **1.5Hz & 2Hz**





Determination of Damping:

Using "Damped-Sine Curve-Fit" from "Vibrationdata MATLAB GUI" to our filtered data (with oil level at mark A) results in a damping ratio of **ξ =0.0016**



1 damped sine curve fit between amplitude 0.4 m/s^2 to 0.2 m/s^2

Similarly, for different oil levels we obtained following results from two smartphones.

Mark Name`	Curve fit between 1m/s^2 to 0.8 m/s^2		Curve fit between 0.4 m/s^2 to 0.2 m/s^2	
	ξ	ω_d	ξ	ω_d
A	0.0023	1.7124	0.0016	1.7168
B	0.0023	1.7126	0.0017	1.7168
C	0.0023	1.7124	0.0017	1.7168
D	0.0024	1.7127	0.0018	1.7168
Smartphone: Google Nexus 6p (2015) Sensor model: BMI160 Resolution:4.8mm/s^2				

Mark Name`	Curve fit between 1m/s^2 to 0.8 m/s^2		Curve fit between 0.4 m/s^2 to 0.2 m/s^2	
	ξ	ω_d	ξ	ω_d
A	0.0020	1.7152	0.0017	1.7198
B	0.0020	1.7152	0.0017	1.7196
C	0.0020	1.7152	0.0019	1.7199
D	0.0022	1.7155	0.0020	1.7199
Smartphone: Samsung Galaxy S5 (2015) Sensor model: MPU6500 Resolution:0.6mm/s^2				

Conclusions:

- Result shows a very slight increase in the damping ratio **ξ** by increasing the wetted area(oil level).
- Damping ratio is not constant instead it deceases as the amplitude decreases.

References:

[i] -Tom Irvine MATLAB GUI https://www.Vibrationdata.com

[ii] -Vibration analysis using mobile devices (smartphones or tablets)
A.Feldbusch, H.Sadegh-Azar, P.Agne https://doi.org/10.1016/j.proeng.2017.09.543

[iii] In *Wireless Engineer*, vol. 7, 1930, pp. 536–541 - "On the Theory of Filter Amplifiers"-S. Butterworth