iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** V **Month of publication:** May 2021

DOI: https://doi.org/10.22214/ijraset.2021.34664

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue V May 2021- Available at www.ijraset.com

Low Cost Solution for FFT (Fast Fourier Transform) Analyser

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Abstract: Vibration Analysis is a process of measuring the* vibration *signals (amplitude and frequency) of industrial machinery. Vibration signal information can be further used to determine the "health" of the machine, and its components. Vibration analysis is conducted using various sophisticated instruments (FFT analyzer) and its cost is too high, hence most of the time it is not affordable to monitor vibration continuously and analyze the health of the machine. This article proposes low cost system for analyzing vibration signature. Proposed system uses ARDUNIO and low cost accelerometer ADXL for collection of the vibration signal, collected signal is further converted into frequency domain using MATLAB script. Know vibration signal is generated using electromagnetic vibration exciter and ADXL sensor is mounted on vibratory platform and is connected to Arduino and it further records the acceleration signal. Recorded signal is further analyzed using FFT toolbox of MATLAB. It is observed that recorded signal FFT and standard FFT analyzer shows a close matching with each other.
Keywords: FFT, Ardiuno ATMega-2560, ADXL-335 accelerometer, vibration exciter, MATLAB

I. INTRODUCTION

Vibration measurements can be utilized as an effective tool of condition monitoring of machine. Vibration signal analysis is the technique of measuring vibration to identity the interrupted actions in machinery. Vibration analyzers separate vibration signals into amplitudde and frequency domain components to facilitate failure recognition. Vibration generated by any machine contains a set of information about condition of machine. Condition monitoring is a process of monitoring parameters of condition in machinery (vibration, temperature, and noise-level) in order to identify significant change which is indicative of developing fault. It has a pragmatic importance of predictive maintenance. The use of predictive maintenance gives a chance of maintenance to be scheduled or other action to be taken to avoid upcoming damages. This set of information can be used for identifying and locating fault in particular machine. Inertial Micro electromechanical systems (MEMS) sensors are playing vital role in electronics equipment's. Due their compact size, efficient working, low power consumption, usefulness in various conditions. They are used in most advanced electronic instruments. Inertial MEMS sensors are generally non-transitory quality and mollified expense in car wellbeing frameworks permitting them to be used in many cars [1]. The primary objective of frequency analysis is to be convert complex signals into its components at various frequencies, so it is important to be understanding frequency analysis parameters and to interpret the results. [2]. It is esoteric to interpret a time domain data to recognize the unusual change in machine, but in case frequency domain it is quite lucid to analyze. By using MEMS sensors we can measure vibrations and data will be obtain in time domain which can be converted to frequency domain by using MATLAB [3]. MEMS accelerometers provide fast, efficient integration and cost effective solution to rising bunch of latest users [4].

II. EXPERIMENTAL SETUP


Fig.1 Actual setup along with FFT and Ardiuno accelerometer arrangement

The setup consists of electrodynamic exciter which used for the generation of known frequency vibration. This exciter is operated by using amplifier and MATLAB software. For this purpose, a sound wave of known frequency and maximum amplitude for known span of time in MATLAB is programmed. This generated sound wave is given to exciter through amplifier by means of Bluetooth. Amplifier was used to provide a DC current. Exciter was provided with aluminum flat plate on which measuring sensors were placed.

The proposed work is to measure vibration by using accelerometer with arduino. For this purpose the choice of inertial MEMS sensor was ADXL-335 accelerometer along with ATMegaArdiuno board. The external power supply is provided to ardiuno and sensor. The accelerometer is programmed by using Ardiuno software for converting electric signals into acceleration. The various factors like accelerometer sensitivity, environment temperature effects are considered while programming. The data coming from the sensor is processed by ardiuno board and stored with help of PLXQ spreadsheet software.

A. Core Sensing Elements ADXL335 Accelerometer

The ADXL335 accelerometer used in this work is small low power triple axes MEMS accelerometer. The sensor has full sensing range of ±3g. It is capable of measuring static acceleration due to gravity in tilt sensing applications and dynamic acceleration resulting from motion or vibration. The sensor works on power between 1.8V to 3.6V. it has sensitivity ranging from 270-330 mV/g. it work in manner that the movement of detector frame changes the differential capacitor. On chip electronic circuit determines the change in capacitance and transforms it into output voltage [5].

B. FFT Analyzer

FFT analyzer is currently used as a reliable instrument for measurement of vibration. It gives an analysis in both time domains as well as in frequency domain. In this setup, it is used as to compare and validate the data obtained from the accelerometer. For this purpose of comparison measurements on both FFT analyser and ardiuno carried out simultaneously for known frequency on exciter

The data simultaneously recorded from ardiuno as well as FFT analyser is to be processed. The data generated by FFT is in time domain as well as in frequency domain. For proposed work, the data processed in time domain. Similarly, ardiuno also generate data in time domain. The time domain data from both instruments is converted to frequency domain by using MATLAB software.

III. RESULTS

The analyzed data from both of devices plotted in MATLAB. The various graphs are plotted for various frequencies of exciter. From these graphs it is understand that the trend followed by FFT analyser of vibration is quite similar that of ardiuno-accelerometer arrangement.

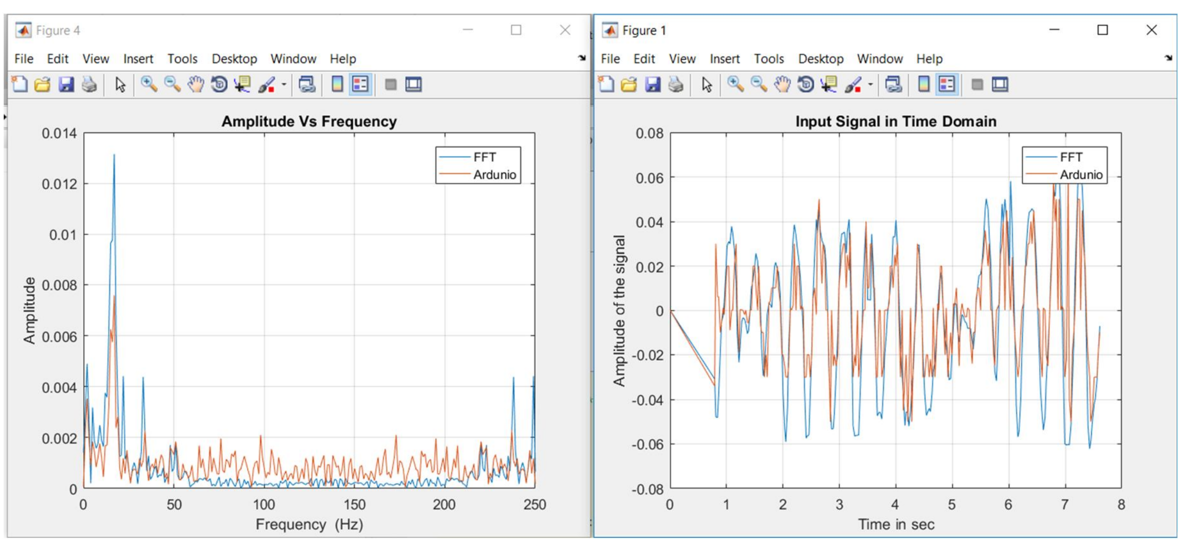

Fig. 2 For frequency 5HZ

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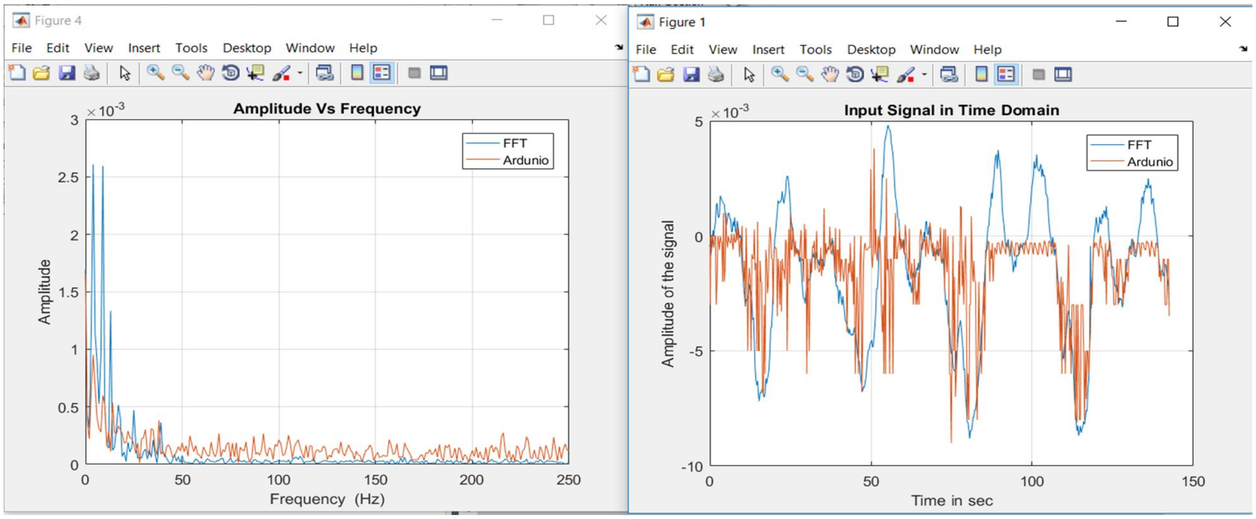

Fig. 3 For frequency 10HZ

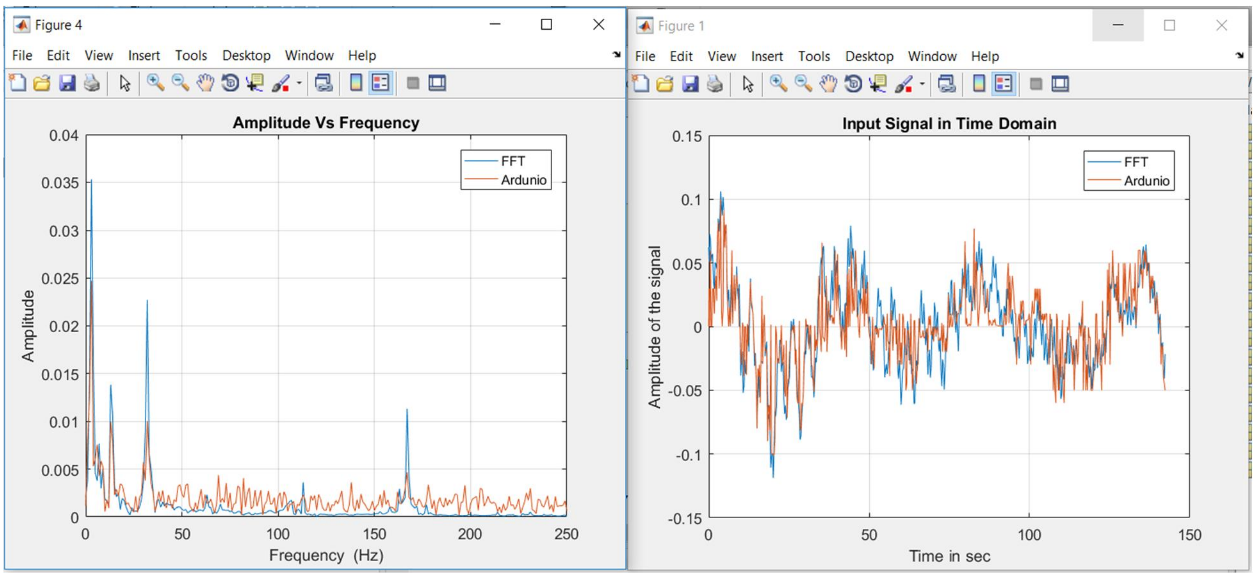

Fig. 4 For frequency 20HZ

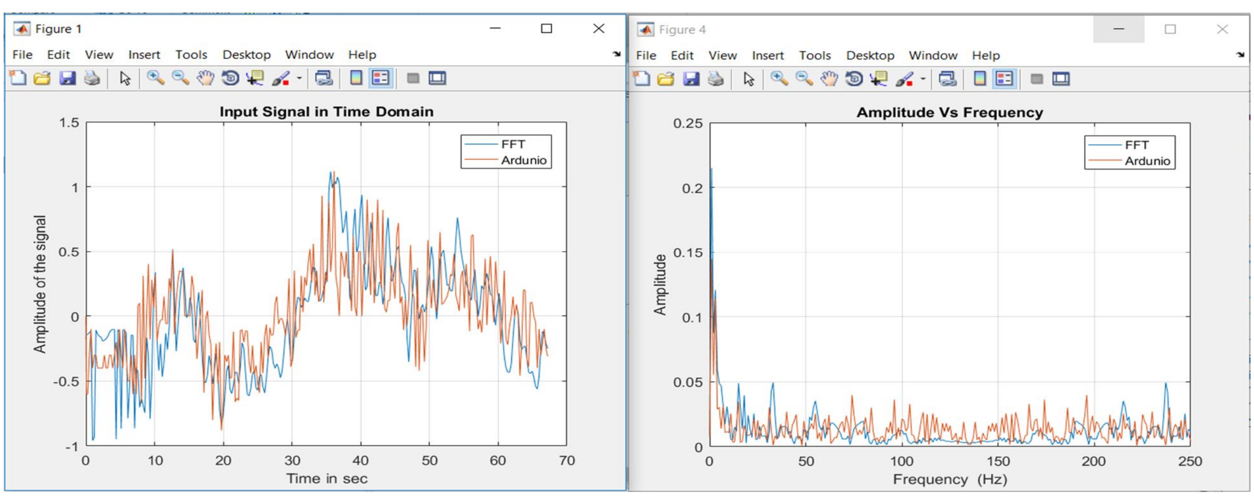

Fig. 5 For frequency 40HZ

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Validation of Accelerometer - Ardiuno setup with Fast Fourier Transform Analyzer (FFT).

In fig. graph shows that peak at starting is shown by FFT and ardiuno both is approximately similar for the all frequencies. Further, the trend followed by both of instrument is also similar. As sound wave is of constant frequency and amplitude vibrations but due to losses in amplifier at exciter it is observed that vibrations are not constant, this is shown by both of devices.

The smooth curve is followed by FFT plot but in case of ardiuno it is not smooth this is evidence that the number of recorded values of accelerations by the FFT is more than ardiuno. At some instant the FFT shows high peak compared to ardiuno this is due to sensitivity difference in between both instruments. At some graphs starting acceleration is much high this is because of jerk.

Peaks represent in graphs shows that there is change in behavior of machine elements. If it shows high amplitude at that frequency means, there is fault in that particular frequency component.

Gears are important part in various industrial applications. For getting unexpected failure of gear cause major losses. The vibration signal of gearbox carries signature of faulty gear and for verification of above purpose, we create some faults in two stage gearbox. We run the gearbox at different speeds and early fault detection of gearbox is possible by analyzing the vibration signal using our purposed setup.

Gearbox produces complex vibration in which inherent operating frequencies, noise and other failure frequencies. Inherent frequencies are the part of baseline signal, which corresponds to speed of gear and gear meshing. The gear mesh frequency is unique for each stage of gear. The general problems occur in gearbox are excessive wear, overload, misalignment of gear, broken tooth, etc. And these problems overcome by using predictive maintenance. Experimental setup done as follow:-

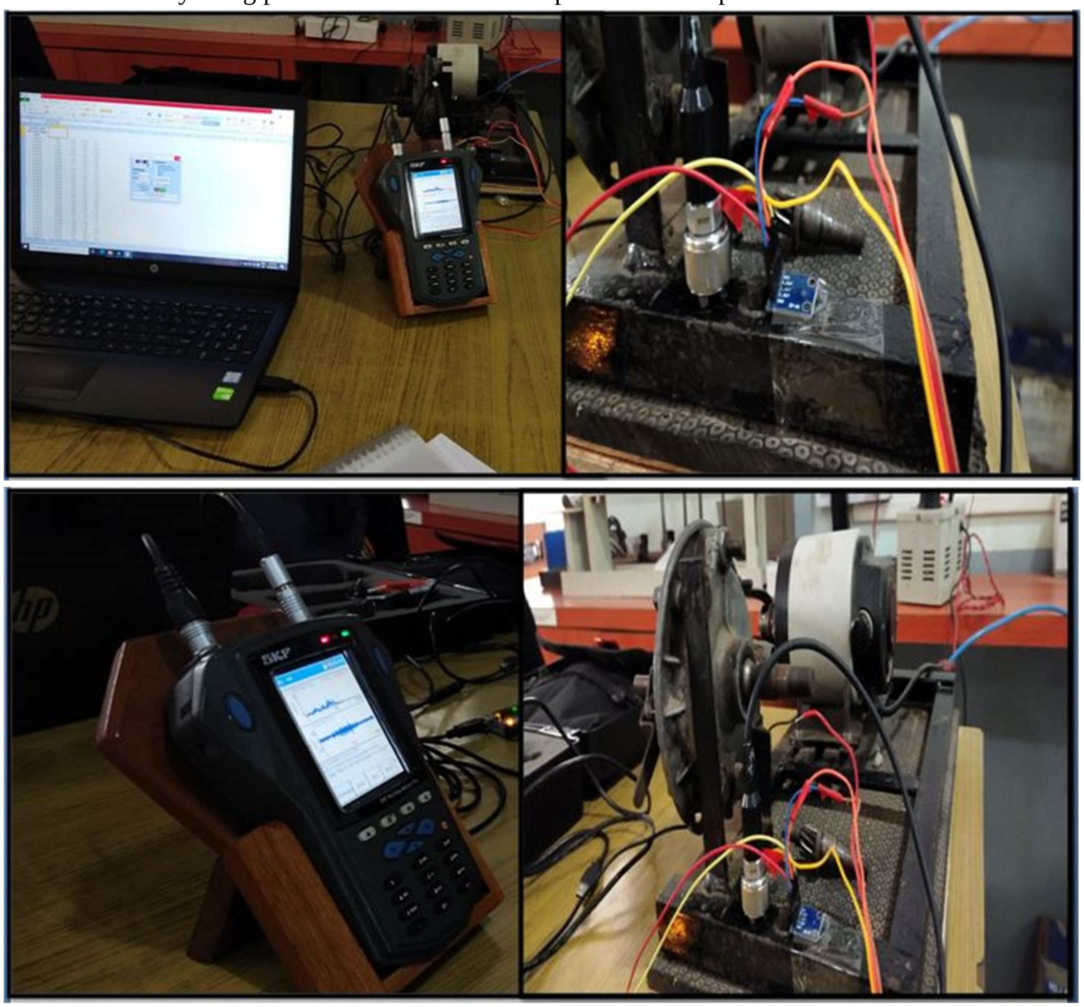

Fig. 6 Actual setup with gear box

After successful setup, we create some errors in gearbox and took some readings.

The error graphs as follows at different frequencies:-

1) *At frequency 60 Hz (Error Created - Imbalance)*

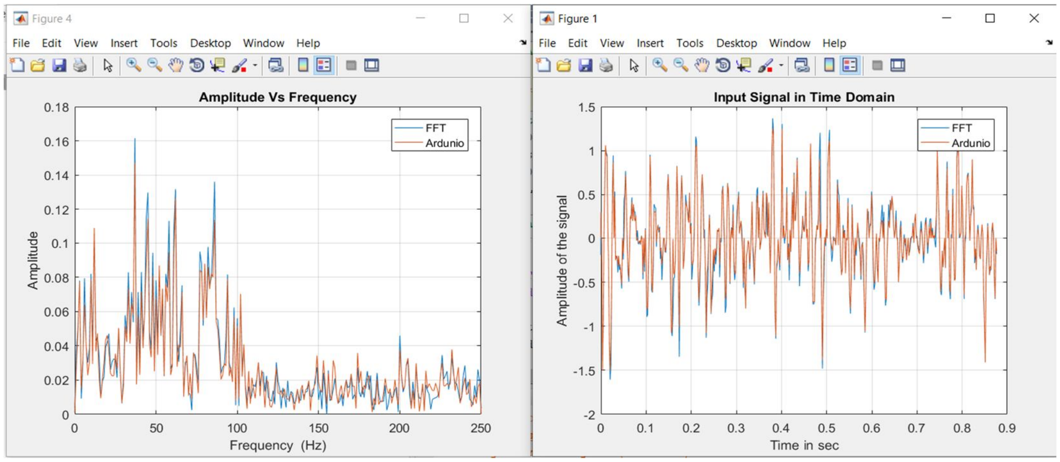

Fig. 7 Frequency 60 Hz - Imbalance

2) *At frequency 80 Hz (Error Created – Broken Tooth)*

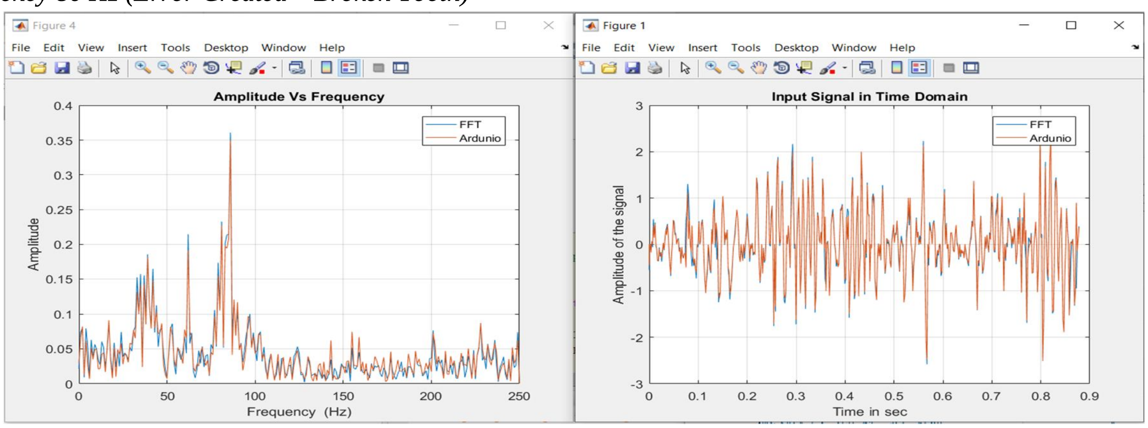

Fig. 8 Frequency 80 Hz – Broken Tooth

3) *At frequency 80 Hz (Error Created- broken Tooth and Imbalance)*

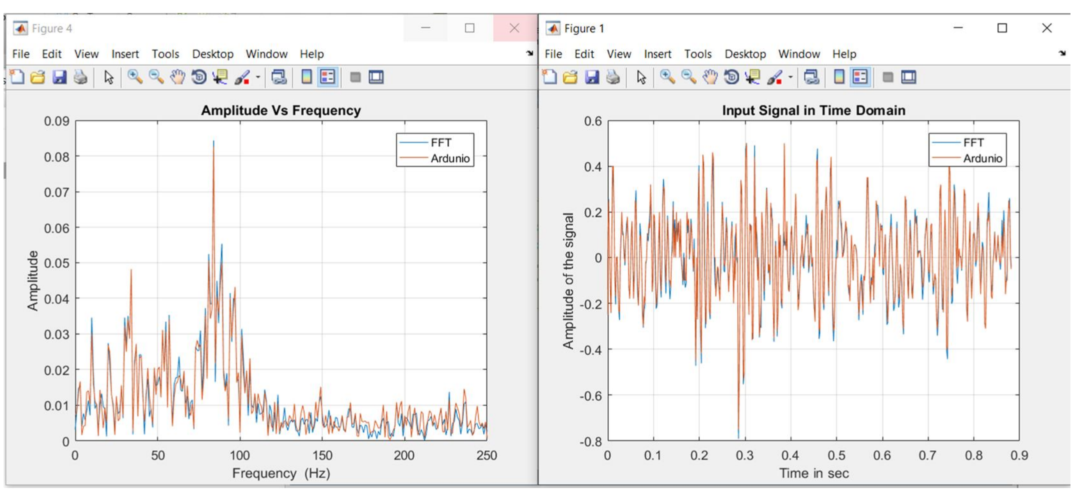

Fig. 9 Frequency 80 Hz - Broken Tooth and Imbalance

4) At frequency 100 Hz (Error Created – Imbalance)

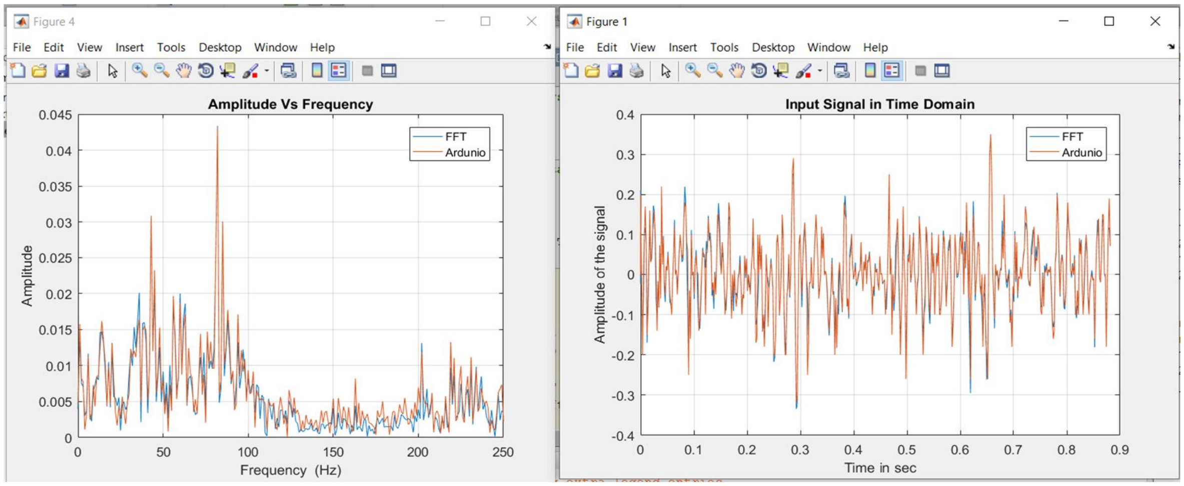

Fig. 10 Frequency 100 Hz - Imbalance

5) At frequency 100 Hz (Error Created – Broken Tooth and Imbalance)

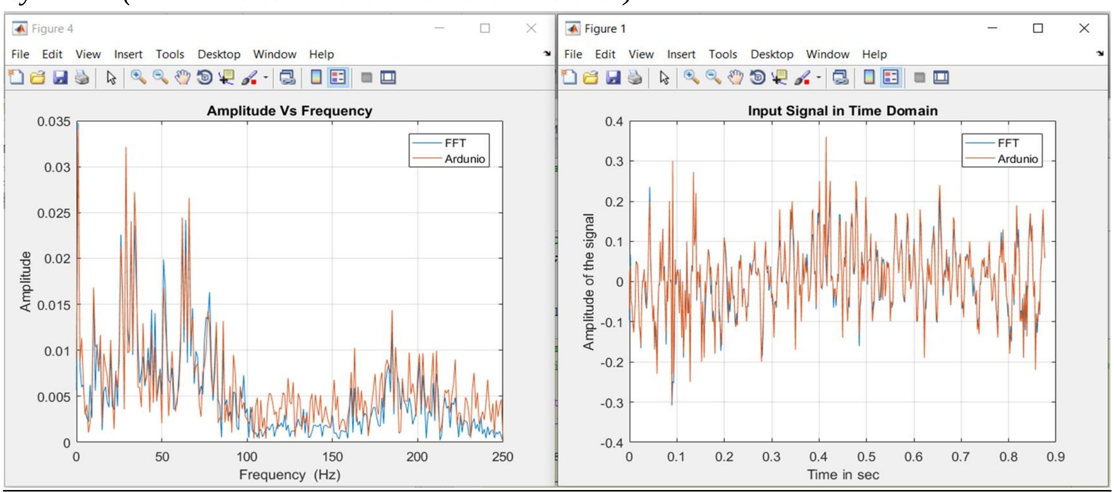

Fig. 11 Frequency 100 Hz – Broken Tooth and Imbalance

IV. CONCLUSION

In present article, proposes low cost hardware setup to collect the vibration signals, which uses ARDUNIO-Uno, ADXL accelerometer. Vibration signal generated using electromagnetic vibration exciter via Bluetooth connection to PC. Signal was generated in the range of 5-Hz to 40 Hz, ADXL accelerometer was mounted on platform of vibration exciter which senses vibration signal and records using ARDUNIO-Uno microcontroller. Recorded signal from ADXL sensor is further analyzed using Fourier transform technique is used to estimate the frequency of signal collected using accelerometer and found close matching with input frequency. Such low cost vibration analyzer is very much useful for signature analysis and fault identification in rotating machineries. Further, results of experiments are validated using calibrated FFT analyzer and show a close match with calibrated FFT instrument.

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