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3D Vibration Monitoring Sensor for Automobiles Using Internet of Things (IoT)

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ABSTRACT

Internet of Things (IoT) is considered to be the backbone of forth industrial revolution. It seeks to create a network of physical objects/processes, omnipresent sensors and computer systems, so as to provide a smart solution to day to day problems by bridging gap between real and information world. Reducing of mechanical vibrations and shocks generated is one of the major challenges in automobile industry. Whole-body vibrations (WBV) are the most serious of all the vibrations. Continuous exposure to these vibrations not only adversely effects human health, but also decreases durability and fuel economy of automobiles. Longer the exposure, greater will be the effect on health. Musculoskeletal disorders (WMSD) like Low Back Pain (LBP), fatigue and numbness of muscles, joint pain etc., are some of the disorders caused by these vibrations. To avoid long-term health risks associated with WBV, vibrations generated in automobiles need to be accurately measured and analyzed. The aim of this paper is to develop a cost effective easy and user friendly sensor for the purpose of frequent monitoring of the excessive vibrations produced in vehicles. This project consists of active experiments conducted on selected structural elements of bike, car and bus. The observations were made in all the three orthogonal axes for different constant rotational velocity (gears), using an arduino based accelerometer.

Keywords: Internet of Things, Whole-body vibrations, musculoskeletal disorders,Low Back Pain, cost effective, user friendly, constant rotational velocity,arduino, accelerometer.

I. INTRODUCTION

The Internet of Things (IoT) is an emerging technology whose purpose is to overcome the gap between objects in the physical world and their representation in information systems i.e., realizing a world where in physical objects are seamlessly integrated into the information network [1]. Facilitating these objects with the possibility to communicate with each other and to analyse the information recorded from the surroundings would generate a possibility of wide range of applications [2, 3]. One such application is monitoring of mechanical vibrations produced in automobiles. These vibrations are produced due to a number of different sources like engine (incomplete combustion, knocking etc.) [4], roughness of road surfaces, gear box (during transmission), tires etc. [5] Periodic monitoring and attempts to decrease these vibrations are very vital, given its adverse effects on heath of passenger/driver, fuel economy and vehicular structure. Whole-body vibrationsoccur when the human body is supported on a surface which is continuously vibrating.As a mechanical and biological system, prolonged exposure to WBV leads to musculoskeletal disorders like low back pain [5, 6], spinal degeneration, muscle fatigue, joint pain, physiological effects such as increase in heart rate, increase in muscle tension, gastrointestinal issues, respiratory disorders, reproductive organ damage etc. [7-10]

The prediction of discomfort caused by WBV is very essential in automobile industry, so as to design a customer friendly vehicles. The injury potential of vibrations is expressed in terms of an average measure of the acceleration (R.M.S. value) [11]. According to ISO standard for a comfortable ride, the rms acceleration must be less than 0.315 $m/s^2$and the vibration is very uncomfortable if it’s more than 1.25 m/s^2. [12]

II. DESIGN OF SENSOR

The sensor (figure 1) designed consists of ADXL 335 triple axis accelerometer (bandwidth: 0.5 to 1600Hz for x and y axis and 0.5 to 550 Hz for z axis), arduino UNO board (ATmega328 microcontroller) and arduino IDE (programming software which interprets code in SKETCH language). Accelerometer was fixed on to positioning pin (figure 3), to be placed on vibrating surface under observation. The output set in serial monitor is at

Figure 1. Vibration monitoring system setup

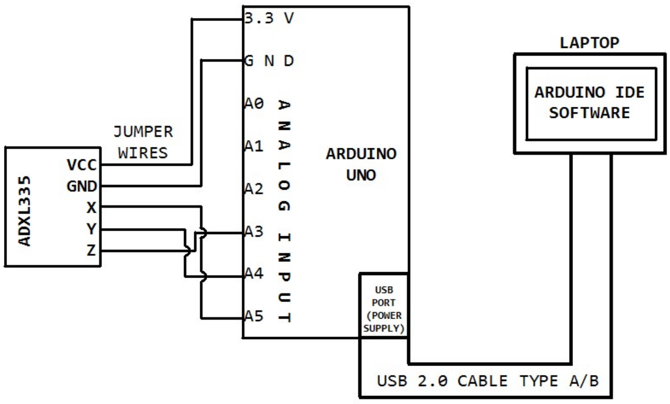

Figure 2. Circuit diagram of the sensor system

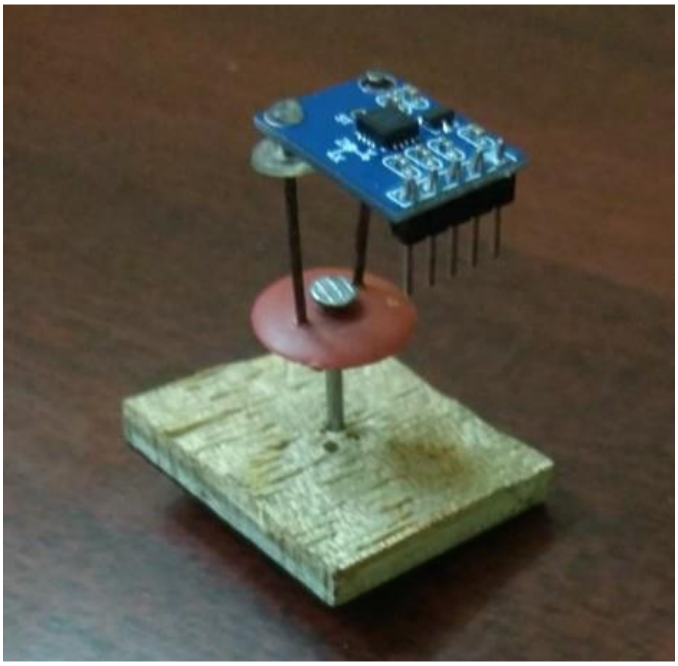

Figure 3. Positioning pin with accelerometer fixed on to it

III. INSTALLATION AND TESTING OF SENOR

A. Monitoring of vibrations in bike

Accelerometer is mounted on the positioning pin which is in turn fixed on to the casing of the gear box adjacent to the engine (94.5 cc) of a bike (Figure 4). Observations were made during neutral state, first gear, second gear, third gear and fourth gear. Corresponding graphs were generated with the help of arduino IDE software.

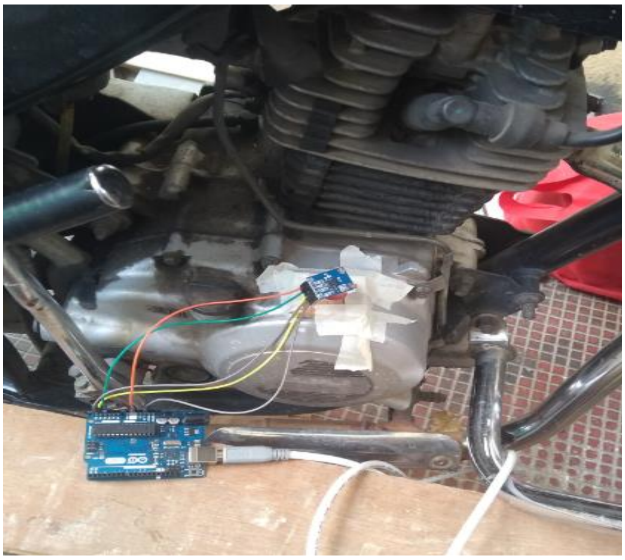

Figure 4. Installation of the sensor to the bike under observation.

B. Monitoring of vibrations in car

Accelerometer is mounted on the positioning pin with thermocol/polystyrene base (functioning as a shock absorber to prevent damage to the sensor) which is fixed onto the casing of the engine (Figure 5).

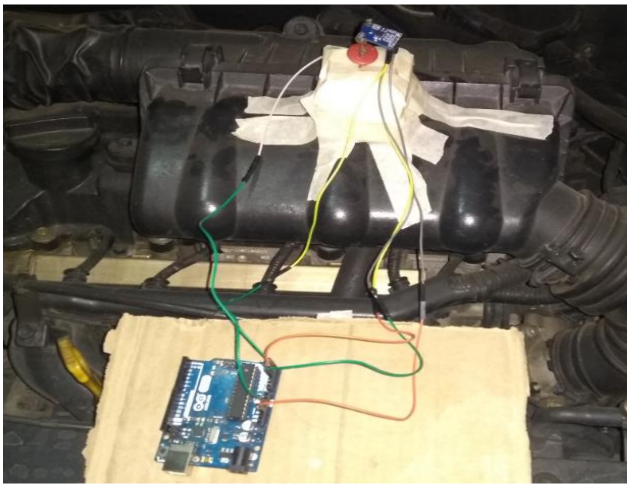

Figure 5. Installation of the sensor to the car under observation.

Observations were made during neutral state with and without acceleration. Graphs were plotted in similar manner as that of the bike.

C. Monitoring of vibrations in bus

The senor system identical to that of the car was fixed to record observations at two different locations that generate most of the vibrations, namely:- tires and the engine (diesel) as shown in Figure 6 and 7 respectively. Tires are complex composites made of rubber, steel and polymers, which absorb and transmit forces generated by the vehicle and the road surface [14]. Graphs were generated using the same procedure.

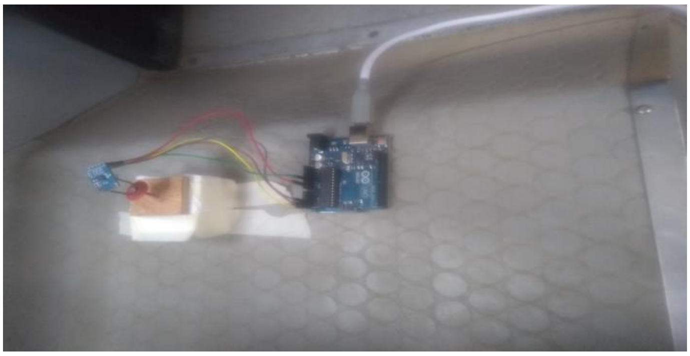

Figure 6. Installation of the sensor above the tire of the bus

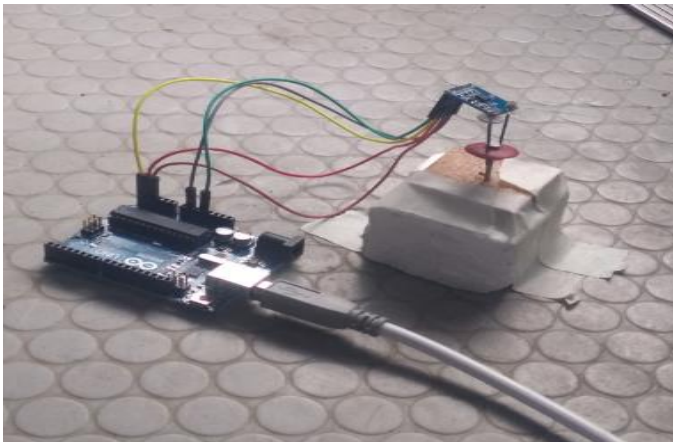

Figure 7. Installation of the sensor adjacent to the engine of the bus

IV. RESULTS AND DISCUSSION

Graphs were plotted, taking the time taken for code to processes two consecutive output statements along x axis and serial data (data from accelerometer along x, y and z axis) along y axis using arduino IDE. The engine of thevehicles are accelerated periodically. X axis is represented by purple curve, y axis by yellow curve and z axis by blue curve. (Special filters were used to improve qualityof the graphs obtained for inclusion in the paper.)

i.Output of vibrational analysis of the bike

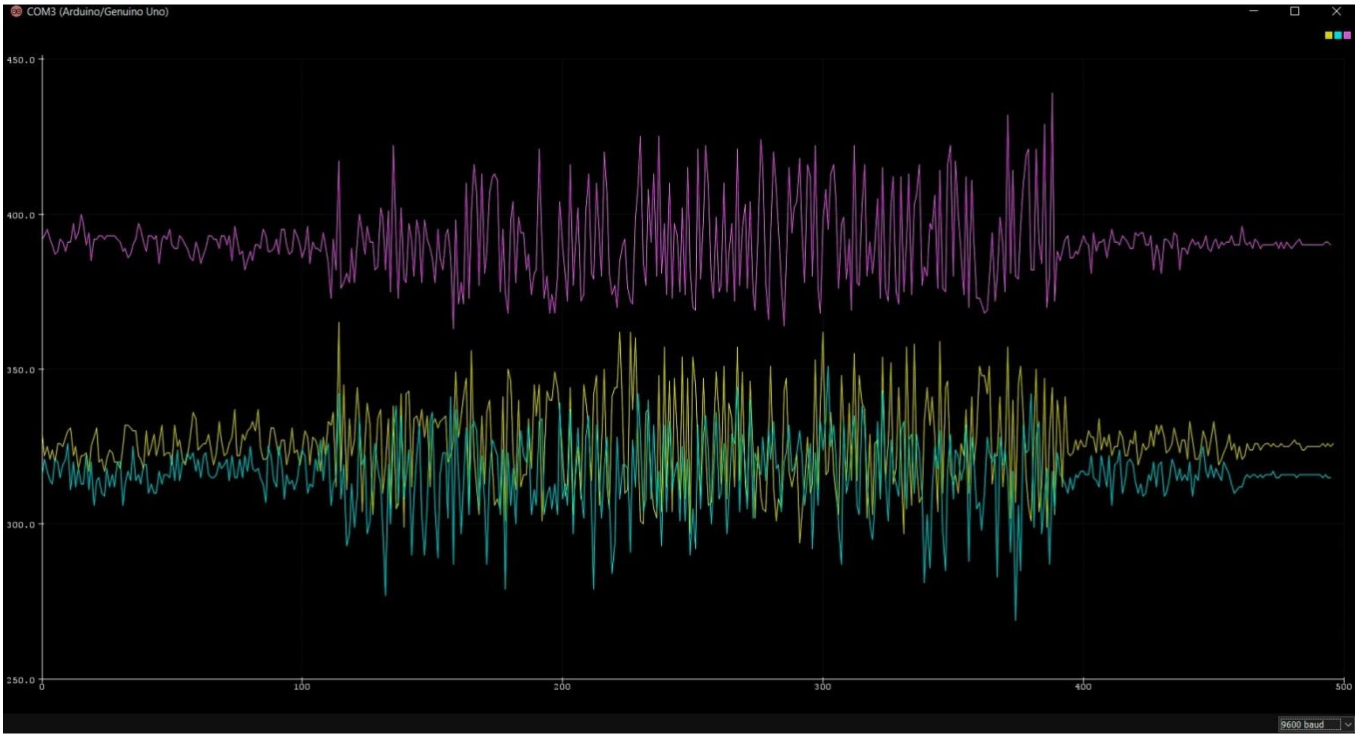

Figure 8. Monitoring of the bike in neutral state

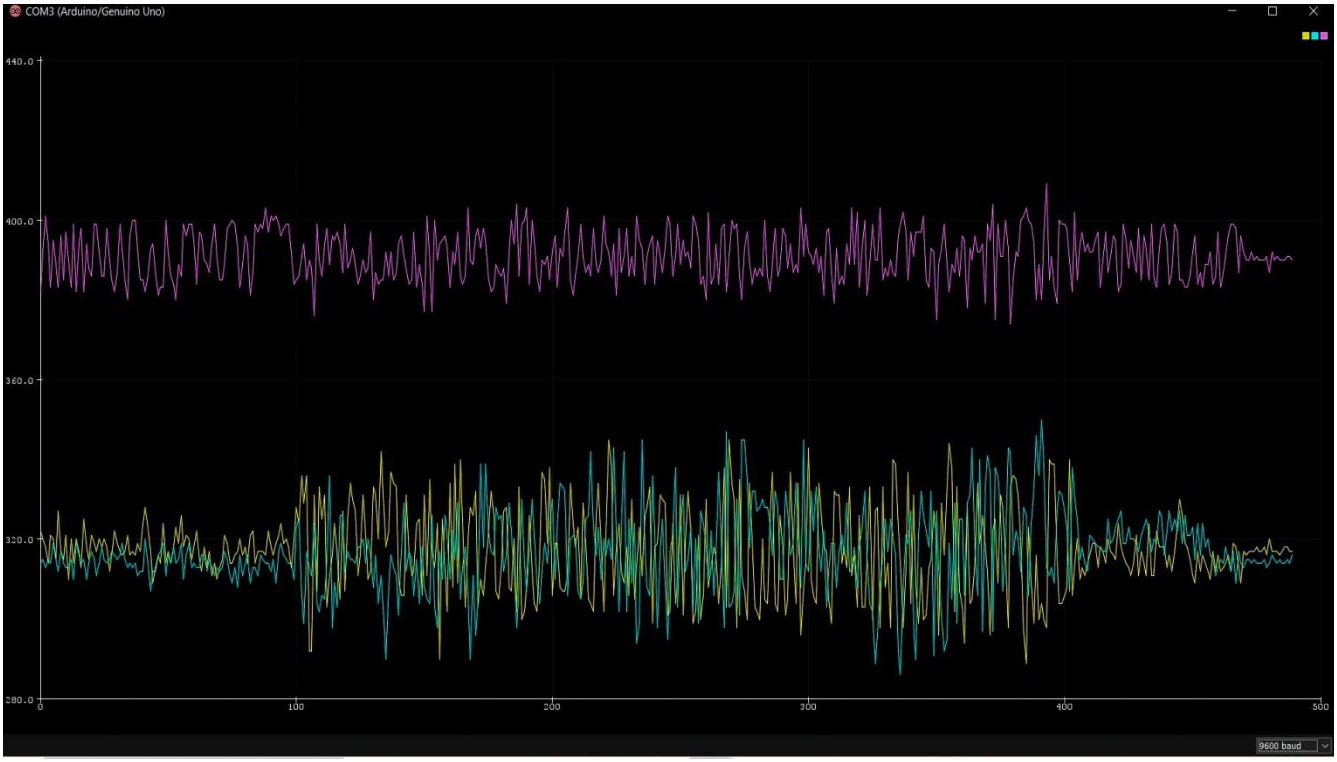

Figure 9. Monitoring of the bike in first gear

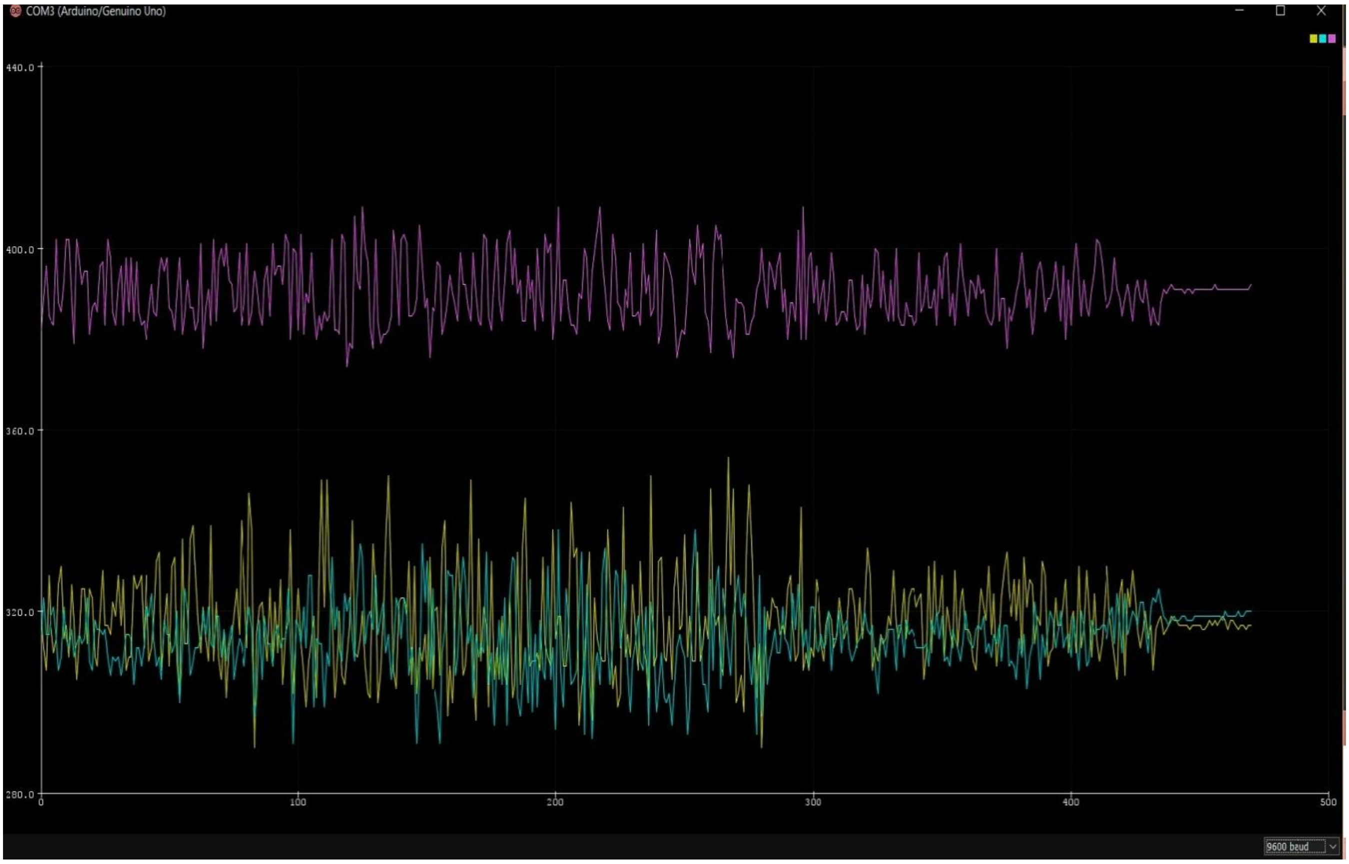

Figure 10. Monitoring of the bike in second gear

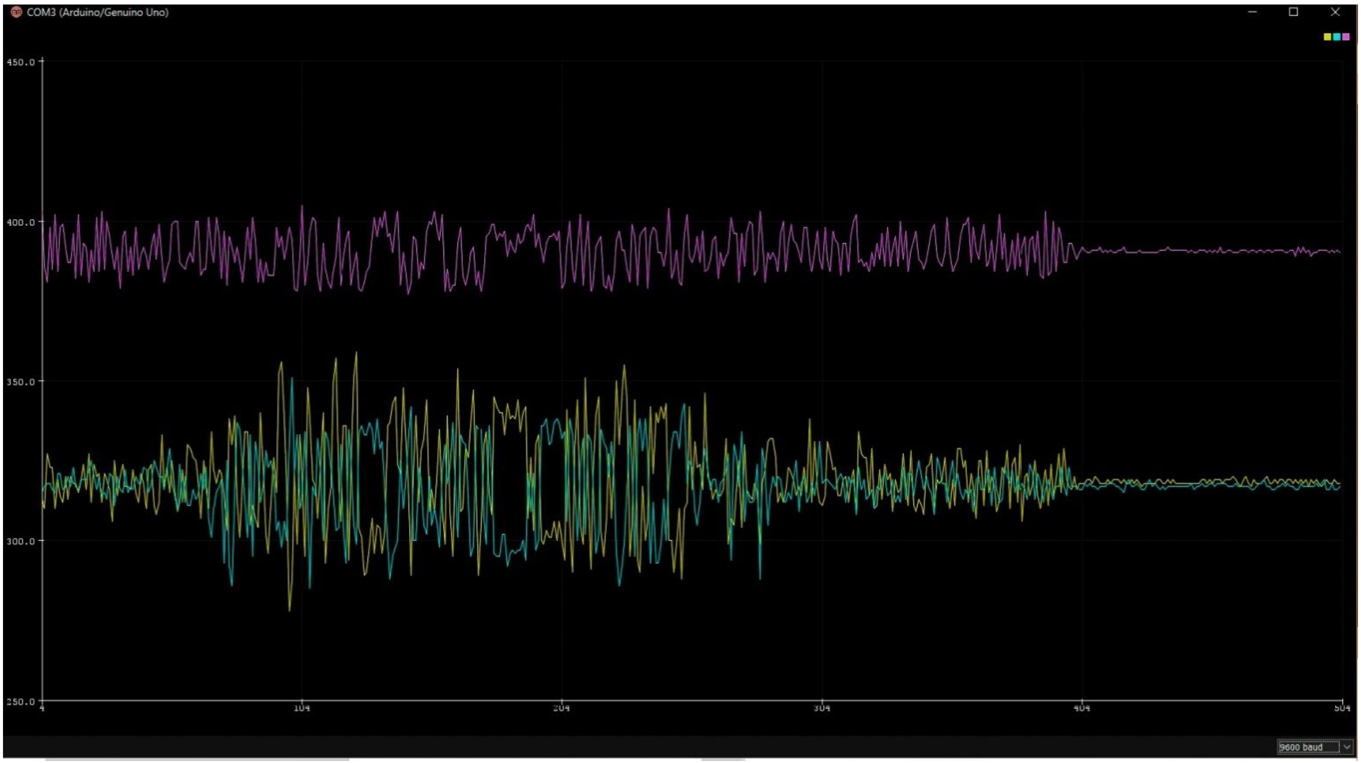

Figure 11. Monitoring of the bike in third gear

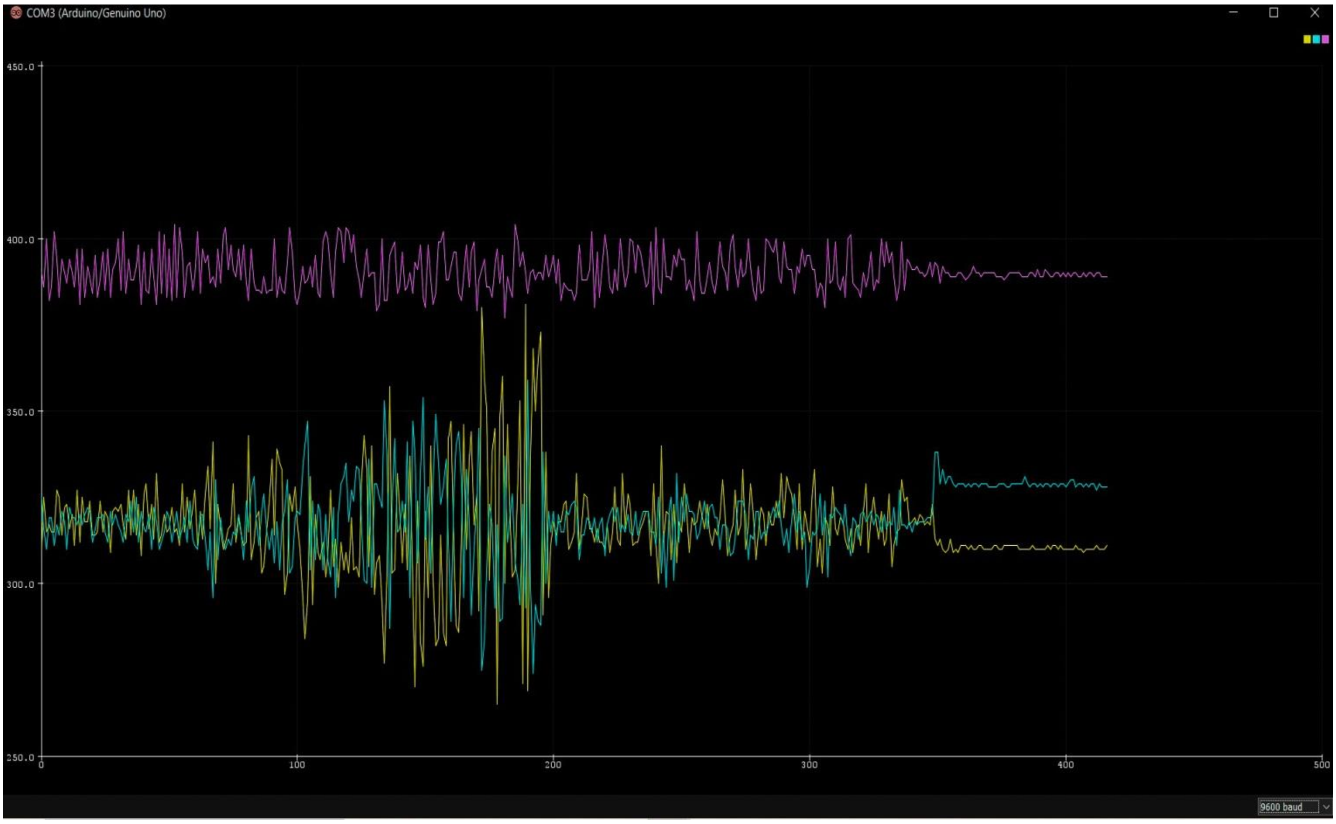

Figure 12. Monitoring of the bike in forth gear

ii.Output of vibrational analysis of the car

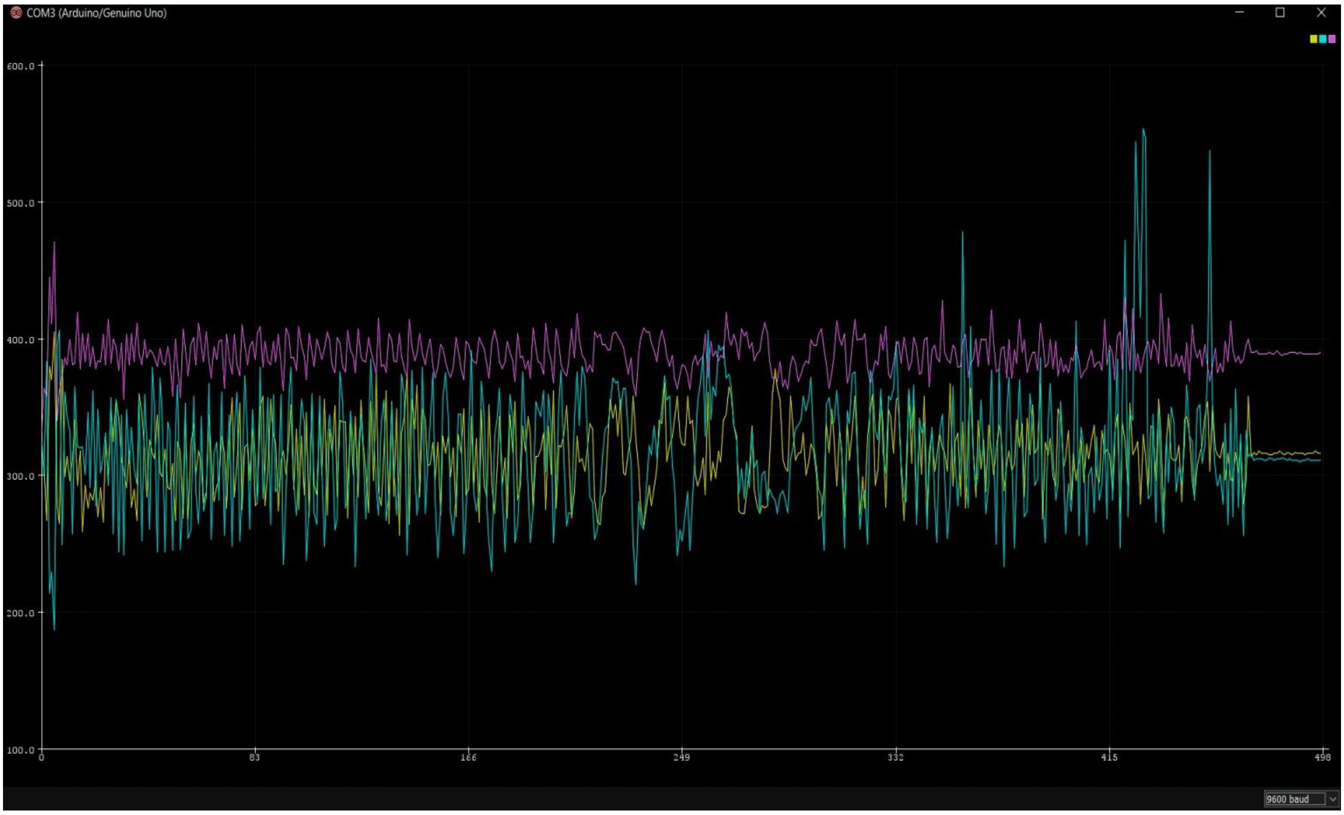

Figure 13. Monitoring of the car in neutral state without being accelerated

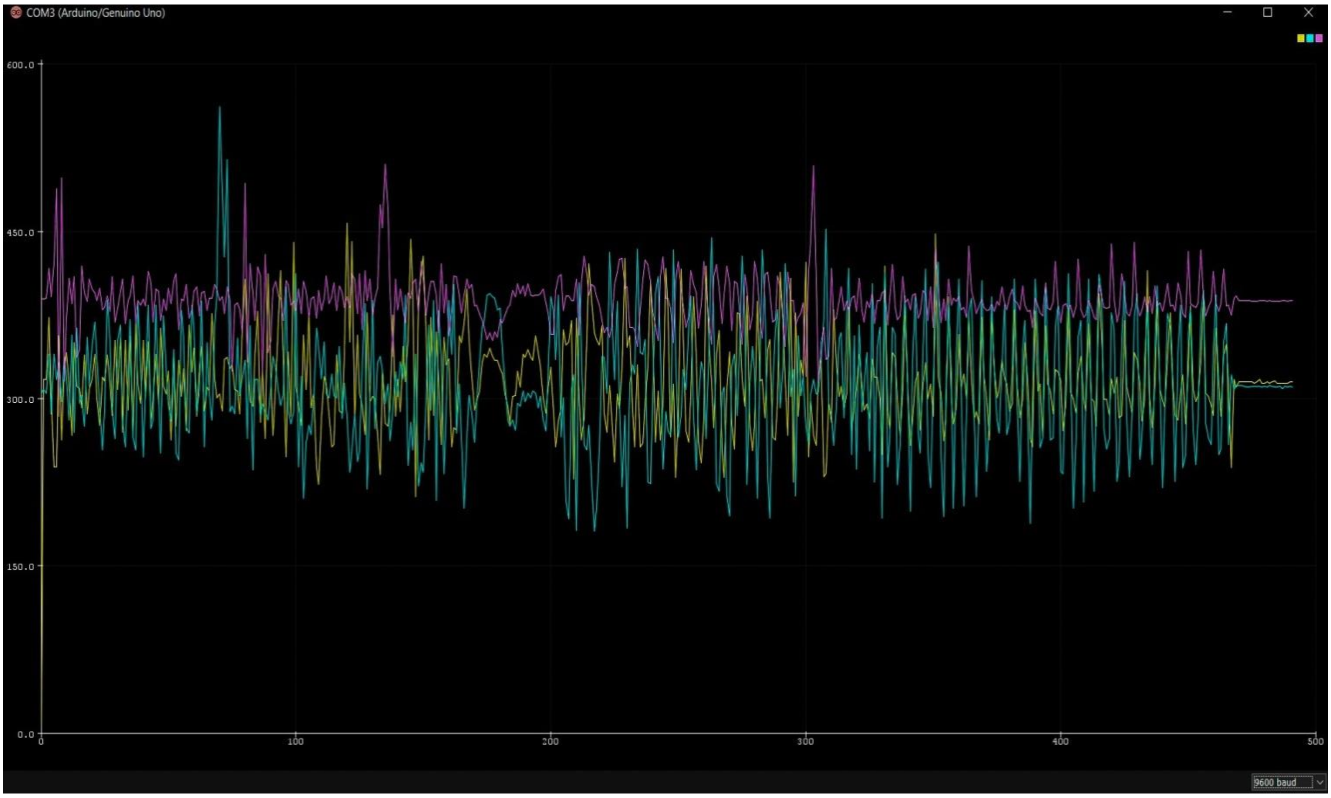

Figure 14. Monitoring of the car in neutral state while being accelerated

ii.Output of vibrational analysis of the bus

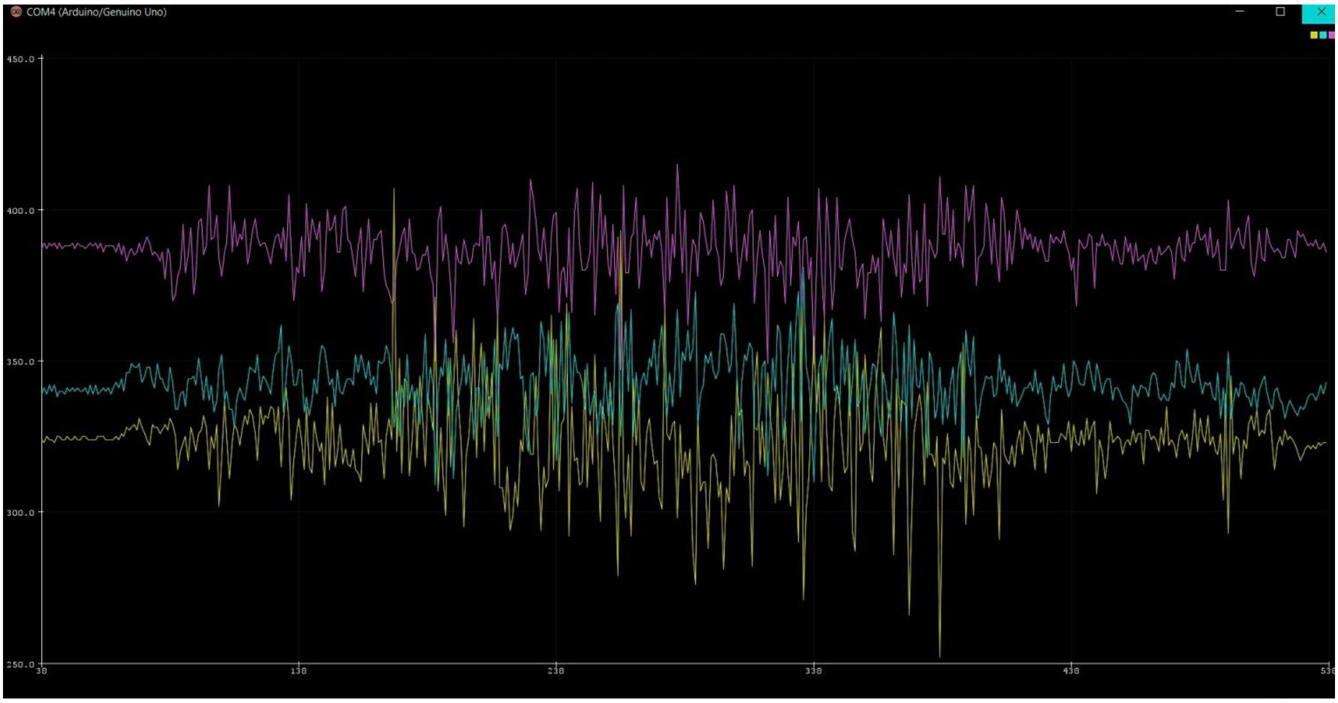

Figure 15. Monitoring of the bus with sensor positioned above one its tire

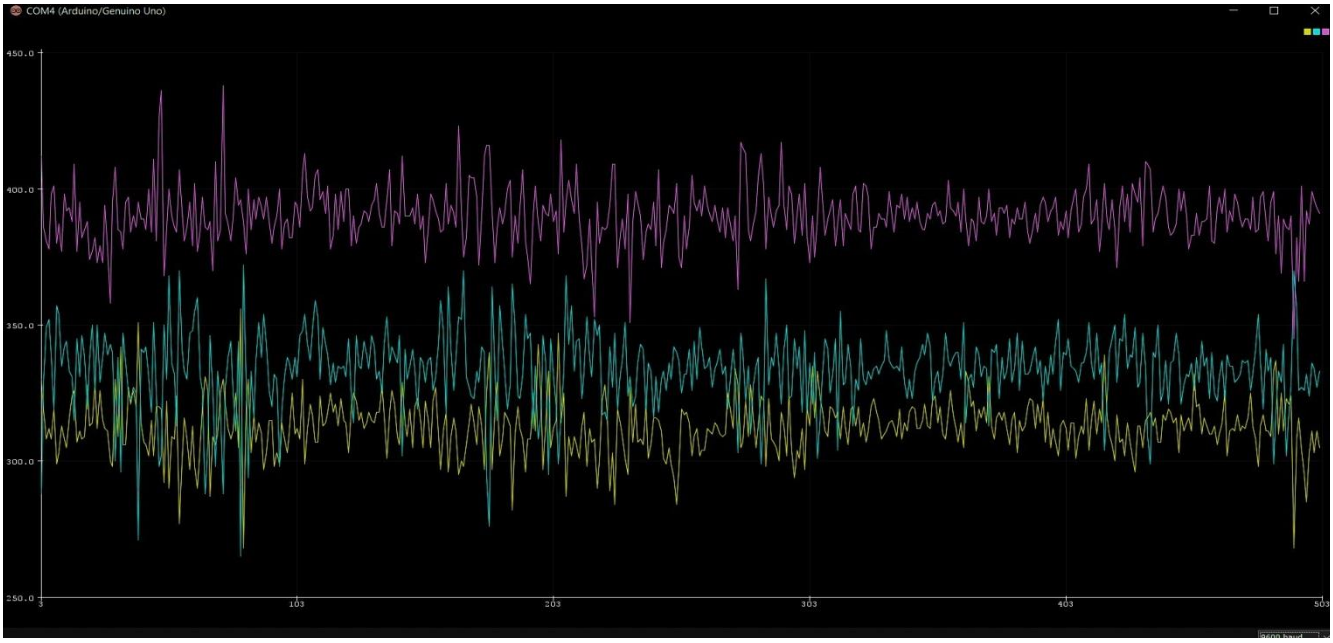

Figure 16. Monitoring of the bus with sensor positioned above its engine

V. ADVANTAGES OVER CONVENTIONAL SYSTEMS

Commercially used vibrational monitoring systems work on different techniques like eddy currents, piezoelectric effect, photonics, capacitive sensing etc. These systems are very expensive and need skilled operator to use them. However, arduino based sensor provides a versatile and an inexpensive cross-platform (compatible with multiple operating systems), with an open source and extensible software and hardware components adding to its credentials. Also, arduino has a very low power and maintenance requirements.

VI.CONCLUSION

Thus, monitoring of vibrations were made in vicinity of key structural components/sources of vibrations for various automobiles as required by this project. Unsteady fluctuations in vibrations generated were recorded over a given time interval by developing a cost effective and user friendly arduino based sensor.

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