Diagnosis & Self Monitoring of Tremor Severity Associated with the Neurological disorders for improving the Quality life style of Elderly Persons

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Abstract-The main objective of the project is to develop a device that can detect the multiple tremor (resting & Action) which includes different Neurological disorders where tremors are in precondition state.The concept of mechanically suppressing tremor achieved through device using IOT base platform, Micro fabrication technologies, various devices characterization techniques for mechanical, electrical and bio-medical. wearable MEMS accelerometer in FEM based Multiphysics simulation software is adopted and it measures the tremor without the help of any trained classifier for identifying the hand tremors in device.An inertial measurement unit (IMU)-based motion capture system to quantify full-body tremor.This Paper proposes a simple method to calculate the variation of capacitance between the moving plates of an accelerometer. If a load is applied on the surface of proof mass of proposed structure, it causes the variation in potential between the plates when one plate is grounded and the other is applied a voltage. With the variation in voltage, there will be the variation in the capacitance between the plates. The capacitance between the plates is measured with respect to variation in distance and voltage.The Simulations are done with COMSOL Multi Physics FEM tool.

Keywords-Capacitance, COMSOL. FEM tool,inertial sensor,inertial measurement unit,MEMS base technology,Parkinson's disease

I. INTRODUCTION

Tremor is an unintentional, rhythmic muscle movement involving to-and-fro movements (oscillations) of one or more parts of the body. It is the most common of all involuntary movements and can affect the hands, arms, head, face, voice, trunk, and legs.The frequency and amplitude of a tremor vary to the degree that the tremor may be hardly noticeable or severely disabling. Frequency can be divided into three categories of oscillation per second:slow (3 to 5 Hz),intermediate (5 to 8 Hz) or rapid (9 to 12 Hz).A tremor has a large displacement whereas a fine tremor is barely noticeable to the naked eye.Tremor may be unifocal,multifocal or generalized and may affect the head, face, jaw, voice,tongue,trunk or extremities[1].Tremor manifests in different types: rest, postural, and action tremors. Rest tremor, which is the characteristic of parkinson's tremor, happens when a body part is relaxed. The postural tremor occurs while a body part is held straight out from the body in a stable position against gravity. The action tremor (kinetic tremor) happens when a voluntary contraction of a muscle follows a certain action—for example, holding a cup . Pure rest tremor is rare. For a PD patient, postural or action tremors appear together with rest tremor, but with different frequencies. A rest tremor may be combined in a postural tremor, but during an action tremor task. An action tremor occurs in most PD; however, the tremor severity is not associated with age or disease duration contraction of the muscles that determines a state oscillatory of all or a part of the body. It can be classified into various types, the most notable in PD are resting tremor (RT), postural tremor (PT) and kinetic tremor (KT). RT occurs when the subject under examination does not voluntarily contracted muscles and maintains the affected part resting on a support such as his own leg. PT occurs primarily in the upper extremities of the body and is characterized by fluctuations faster than the RT. It can be observed when the patient keeps the limb and lying stationary in opposition to the force of gravity as holding the arm in front of the body and tends to disappear when the muscles are relaxed. KT occurs during the execution of voluntary movements such as those can be made to grasp an object, writing or touching the tip of the nose. Parkinson tremor (oscillatory movement) is the central symptom of PD, presenting in about 70% of PD cases Tremors often begin from one finger and expand to the

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whole arm, with the rhythmic back-and-forth action called the "pill-rolling" tremor. Parkinson's disease (PD) is a widespread illness second in incidence only to Alzheimer's disease over age 40. It is estimated that in 2030 there will be about 9 million sick only in the countries of Western Europe [2][3] .It is due to chronic and progressive degeneration of the nervous struc-tures that make up the extrapyramidal system. It is a disorder characterized by the degeneration and death of dopamine producing neurons. When they decreased of 30% appear the first symptoms of the disease such as bradykinesia, rigidity and tremor [4]estimated that 1% of 70-year-olds suffer from Parkinson's disease (PD). At present, about four to six million people are PD patients, in which about 10% of PD patients are younger than 50 years old . Due to demographic increase of the elderly population, PD will occur more frequently in the future.

In the modern world, MEMS have outperformed many conventional fields like bio technology, medicine, communications, automation, manufacturing and made its mark. These miniature devices do more than their size in many ways. More over their simple circuitry and robust nature made them widely acceptable. The significance of these devices is fetched by their reliability, small size, low cost, low power consumption etc. The variety of devices range from pressure sensors to positional sensors and type of measurement from actuation to acceleration. Actuation is a measurement of the act performed by the particular device. In simple, its operation is in negation to a sensor. It can be of any type like hydraulic, electrical, mechanical and pneumatic.Here in this paper capacitive actuation is observed. Electrical voltage is given as input and displacement of the plates is observed as action. The change in capacitance and various other parameters determines the sensitivity of the device. The main advantage of these electrical actuators in MEMS is low electric power is sufficient to obtain the desired results and the given input is almost clean from external environmental issues. They offer high precision, less noise and immediate feedback responses have as objective clinical monitoring of patients with motor dysfunction through the use of inertial sensors.In particular,for patients with Parkinson's disease, accelerometers and gyroscopes have been used to quantify bradykinesia [5], rigidity [6] and tremor [7] [8] . In all these studies data analysis is done offline and the medical does not have the ability to immediately view the results of the tests. Therefore it is essential to have a tool which enables the real-time reporting so that the doctor can get immediate feedback. The ability to save the captured data for each medical examination allows us to immediately compare it with previous examinations and evaluate the time volution of the disease together with the effectiveness of drug treatment. Consequently, a device capable of evaluating the tremor is a useful aid in diagnosis and therapy of PD.

In this study we report results obtained by means an easily usable system constituted by a wearable IMU sensor node that can be employed for clinical diagnosis of tremor and real-time quantification of relative severity.

II. LITERATURE SURVEY

A huge amount of research work has been performed on 140 research papers from different portals to provide a low cost and efficient way for controlling the tremor.Hand tremors are rhythmic movement with oscillations in one or more parts of the body. Parkinsonian tremor is the most common disease that affects approximately 3.8 million people around the world. With frequent diagnostics, we can detect tremor in patients and apply appropriate treatment. The most commonly used system by doctors to differentiate the various types of tremors is using the Electromyography technique. Everyone is not capable to afford EMG for repeated tests as it is very costly and requires frequent check-up to assess the patient's condition and improvement. This section contains a review of a few of those methods to measure and characterize tremor . Xiaochen Zheng and Joaquín Ordieres-Mere.,had proposed a novel data analysis method which is used to detect tremor based on frequency difference and voluntary actions a human movement monitoring system based on smart devices and noSQL used to collect data such as time location arm angle etc.from individuals as well as different methods used to detect and quantify tremor example accelerometer,gyroscope and electromyography. Wearable sensors for long term monitoring find uncomfortable due to large size of device which is time consuming process and need collaboration between engineers,computer scientist and clinicians are require to identify relative information that extract from accelerometers.Debjyoti Chowdhury paper had proposed handheld self stabilizing device consists of a MEMS accelerometer generates a stream of acceleration data for the hands tremor system recorded in Parkinson's disease patients.They developed MEMS based self implemented device is largely different from the current and existing solutions which involve the use of devices that generally bulky and painful to use. Some such solutions also make use of non-standard cutlery which not that easy to obtain.Tremor severity devices are not well commercialized in the market and in the aspect of research most of them are working on improving the quality of life by different methods and very few are working a device that can monitor tremor. Research and Development of such device might be having the importance in aspect to society importance. The main novelty of the work is associated with development of the device that detects multiple tremor's which was not approached in past (targeted only on kind of tremor). Use of MEMS base technology for improvement of such device makes the device miniaturized and can be used Patch sensor and wearable sensor module for the future.here are many approaches to measure hand tremor. This work proposes a method where an embedded system with Wi- Fi (IOT) is used which would replace the most complex and costlier methods. This system consists of various components like

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the inertial sensor, accelerometer and gyroscope. This determines the position and vibration of the hand. A sensor is designed which is based on the capacitive actuation mechanism that detects in the frequency of the tremor. Major challenge in these kind of devices lies in designing a micro scale devices which should intended be like a wearable. As tremor frequencies associated with the neurological disorders are very low and it will be in Hertz.

The proposed model consists of a wearable device to finger with Accelerometer sensor. As the main parameter for detection is the resting tremor, the displacement of proof mass of the accelerometer sensor varies with the tremor frequency which in turn varies the output voltage of the sensor.The methodology that was opted towards the design and development of the sensor was started with the design and analysis of the structure that can yield the low frequency upon the external vibrations using FEM base tool. That was considered as Proof of concept for the fabrication to be carried forward. Upon with using the method of Micro fabrication process flow the device is developed initially with silicon base technology (as Substrate) where the surface layers are deposited using Thermal Evaporation and CVD methods.

III. METHODS AND MATERIALS

A.variable capacitance

Most of the available devices in market are piezo-electric but they also have their limitations in operating temperature and many other factors like sensitivity, damping ratio, pull in voltage etc.. With the all above disadvantages, an advanced technique which is sensitive to variations in aspects like displacement is proposed. For both the static and dynamic applications it gives accurate frequency response as its natural frequency which in other terms conveys that the sensitivity levels are high. When a force F is applied to one of the plates of the system, the capacitance is varied accordingly when displacement occurred due to force applied on one of the plates.

$$C= eA/d$$

where, e= dielectric constant

A = area of the parallel plates

d = distance between the two plates

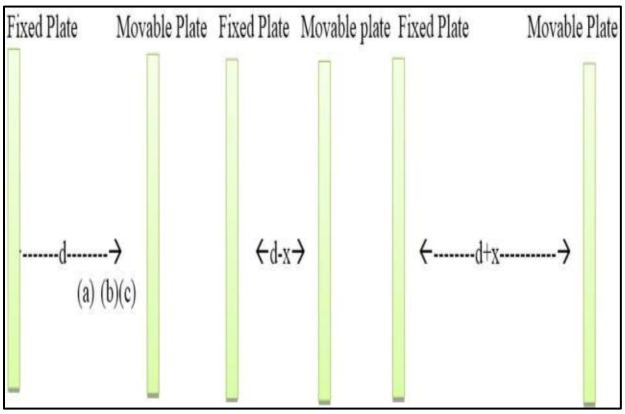

Figure 1 : Fixed and movable parallel plates with varying distance x

The capacitive variation can be observed from the Figure 1and variance represented by the equations shown below. When movable plate is moving towards fixed plate:

$$C = eA/d-x$$

And when movable plate is moving away from fixed plate:

$$C =eA/d+x$$

In electric actuators, the plates move with the change in polarity of the electric charge carriers. If any change in polarity occurs the movable starts to move in opposite direction. The amount of charge present is considered to be constant irrespective of its polarity then the voltage and capacitance are inversely proportional to each other which is represented as:

$$Q = CV$$

Here Q = charge in Coulombs,C = capacitance in Farads and V = voltage in volts

B.sensitivity

The MEMS sensors sensitivity generally depends on the frequency i.e. inversely proportional to the square of it. It is the voltage identified in terms of *g*. The frequency depends on spring constant and mass of the system. Mass is dependent on the dimensions and material of the system. Spring constant depends on E. Here in this case, the change in capacitance describes the response of the sensor for an applied input which is indeed considered as the sensitivity of this device.

C.Inertial Sensors

Inertial sensors are sensors based on inertia and relevant measuring principles. These range from Micro Electro Mechanical Systems (MEMS) inertial sensors, measuring only few mm, up to ring laser gyroscopes that are high-precision devices with a size of up to 50cm. Inertial sensors for aerial robotics typically come in the form of an Inertial Measurement Unit (IMU) which consists of accelerometers, gyroscopes and sometimes also magnetometers.Inertial sensors are composed of accelerometers and gyroscopes, which measure specific force and turn rate, respectively. The so-called inertial measurement unit contains three mutually orthogonal accelerometers and three mutually orthogonal gyroscopes. Therefore, the acceleration and turn rate measurements are triads.11.Inertial sensors based on micro-electromechanical (MEMS) technology have improved its performance over the last decades. However, using MEMS-based inertial sensors the resulting positioning is less accurate than using other technologies like solid state accelerometers or optical gyroscopes (Woodman, 2007).

Magnetometers, which are commonly embedded together with the inertial sensors, measure magnetic fields, e.g., the Earth's magnetic field. Usually, a magnetometer unit is formed by three mutually orthogonal magnetometers. MEMS-based magnetometers are frequently found in smartphones and similar electronic devices.

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D. Accelerometers

Accelerometers are devices that measure proper acceleration ("g-force"). Proper acceleration is not the same as coordinate acceleration (rate of change of velocity). For example, an accelerometer at rest on the surface of the Earth will measure an acceleration g= 9.81 m/s^2 straight upwards. By contrast, accelerometers in free fall orbiting and accelerating due to the gravity of Earth will measure zero.

E. methodology and Work plan

An inertial base sensor methodology was adopted to develop the Sensor that was intended for the tremor detection and Monitoring. Most of the neurodegenerative device's prognosis starts with the tremor as major initial symptom. And this even often observed in muscular disfunction and weakness at the elder ages. As the most of Neurological disorders tend to start at age above 50, the maximum suffering are aged. Identification of the tremor is very crucial in analysis of the physical and Physiological aspects of the aged as it was primary and quality of life Degrading parameter.

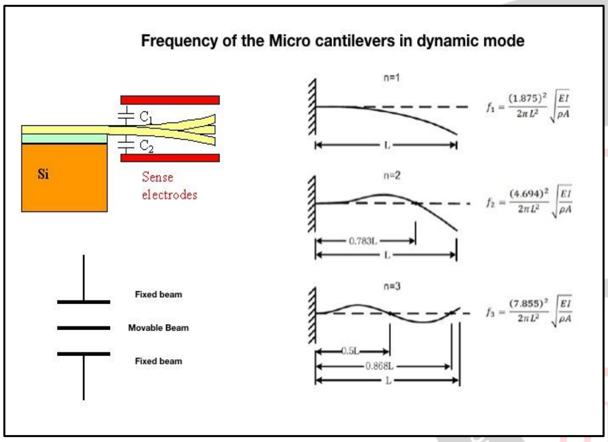

Figure 2: frequency of the micro cantilevers

Here in this proposal, a sensor is designed which is based on the capacitive actuation mechanism that detects in the frequency of the tremor. Major challenge in these kind of devices lies in designing a micro scale devices which should intended be like a wearable. As tremor frequencies associated with the neurological disorders are very low and it will be in Hertz., needs to bulky devices that can vibrate at that low frequencies. As this depends upon the formula of which mentioned in eq.1

f= sqrt(K/m)……….. eq.1

Where K - spring constant of the device and m is mass, The device is modelled by the basis of using dynamic mode excitation of the micro sensors, where capacitive base actuation was used.

Beams studied in this paper are long, thin, cantilever beams above figure shows such a beam. Figure 2 Layout for the device structure with proof mass suspended by stepped beams. One end of the beam is fixed, while the other end is free.Measurements of thin film properties are difficult when compared to bulk materials. The device designed in the paper includes a suspended proof mass that is confined within a fixed frame through step sized electrode structures. These electrodes are used here to attain a lower value of eigen frequency so that it can be matched to the frequency of ambient environmental sources and sharp peak of resonance can be attained. The outer fixed frame is used to support the electrodes and the structure. The whole structure is made up of silicon. The ability to detect the motion of a cantilever beam with nanometer precision makes the cantilever ideal for measuring bending. A straight, horizontal cantilever beam under a vertical load will deform into a curve. When this force is removed, the beam will return to its original shape; however, its inertia will keep the beam in motion. Thus, the beam will vibrate at its characteristic frequencies. This change causes the frequency of vibrations to shift. If the frequency shift is measured. The main aim of my work is to detect the severity of restingtremor for Parkinson's disease at an early stage. The proposed model consists of a wearable device to finger with Accelerometer sensor. As the main parameter for detection is the resting tremor, the displacement of proof mass of the accelerometer sensor varies with the tremor frequency which in turn varies the output voltage of the sensor. The capacitive technique, the two plates are separated by a distance. The variation of capacitance with the change in distance between the plates.

C= eA/d

One of the two plates (electrode) of the capacitor is fixed and another is moving proof mass, when a force is applied, the proof mass moves in a direction which causes variation in capacitance. if no force is applied the output voltage is zero. As major sensing mechanism in mechanical base devices are, beams, cantilevers and diaphragms etc. which are used to sense the external physical parameters that like vibration etc. By mild. Modification of these structure, can be made feasible for the desired outcomes of the particular problems. The methodology that was opted towards the design and development of the sensor was started with the design and analysis of the structure that can yield the low frequency upon the external vibrations using FEM base tool. That was considered as Proof of concept for the fabrication to be carried forward. Upon with using the method of Micro fabrication process flow the device is developed initially with silicon base technology (as Substrate) where the surface layers are deposited using Thermal Evaporation and CVD methods. Using Photolithography, design is patterned, and then sample was subjected to the etching and release of the mechanical structures. A second phase of Lithography is carried to make the contacts if necessary. Once such device fabricated, is subjected to characterisation for structural and morphological studies using AFM and SEM. For electrical characterisation, studies like IV- CV measurement determines the charge developed in the device for particular force applied, which is used calibrate the resolution of the device.This device is packed and integrated with micro-controller and enablement with IoT base platform, to make

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into wearable kind that was tested with the Aged person suffering with the tremor.

IV. RESULTS AND DISCUSSION

The deflection of the system that is confronted in the form of displacement is illustrated in Figure 3.

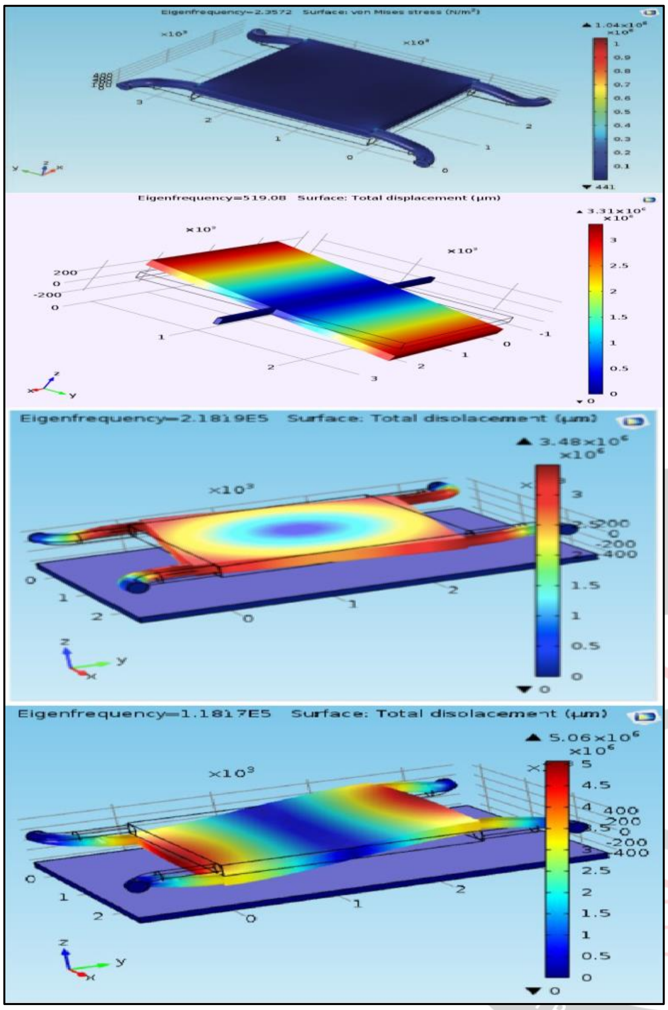

Figure 3: Different eigen values and its displacements

The microcantilever is an ideal displacement sensor.Cantilever bending can be related to adsorption/desorption of molecules through adsorption forces. As molecular reactions on a surface are ultimately driven by free energy reduction of the surface, the free energy reduction leads to a change in surface stress. Although they would produce no observable macroscopic change on the surface of a bulk solid, the adsorption-induced surface stresses are sufficient to bend a cantilever if the adsorption is confined to one surface. Adsorption-induced forces, however, should not be confused with bending due to dimensional changes such as swelling of thicker polymer films on cantilevers. The sensitivity of adsorption-induced stress sensors can be three orders of magnitude higher than those of frequency variation mass sensors .For the respective eigen frequency values the displacement is obtained in um. It proves the phenomenon that eigen frequency values are inversely proportional to displacement.

The values perfectly conclude that with the increase in voltage the capacitance is decreased in the levels of pf. This proves from the equation above Q = CV, which clearly indicates that capacitance is inversely proportional to voltage. The capacitance is also decreased when the distance between the plates is increased in steps of 100um which is a basic concept that when distance increases the strength of the parameters decreases. To optimize the nature of the plates with good capacitance values it is preferable to reduce the distance between the plates to an extent.

A.simulated Results

This paper emphasizes on the usage of COMSOL Multiphysics as the basic MEMS tool to perform Static Analysis, Modal Analysis.Static Analysis refers to the plot of displacement vs. voltage applied to a switch when it is being subjected to an externally applied electrostatic actuation. It aids in obtaining the amount of actuation voltage required to achieve the down actuated state configuration from the up.Figure 4shows the deformed shape of the beam when subjected to the required actuation voltage. Figure 5 shows the Displacement (nm) vs. Electric potential (V) curve showing an actuation.

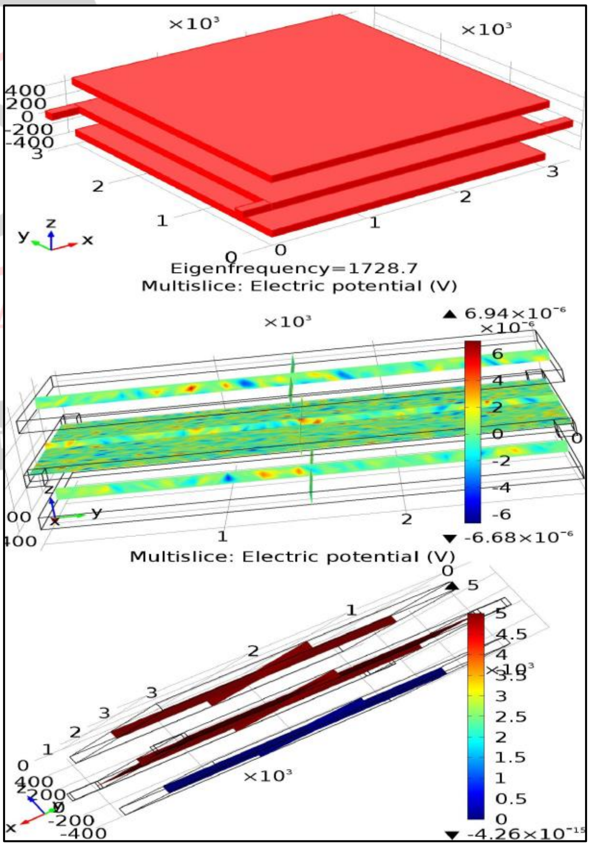

Figure 4:Actual and Deformed shape of the beam when subjected to the required actuation voltage.

However, in order to perform accurate simulated Static Analysis in COMSOL Multiphysics, the various application modules used are-

MEMS Module

Structural Mechanics Solid,Stress-Strain

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Static Analysis

COMSOL Multiphysics

Deformed Mesh

MovingMesh(ALE)

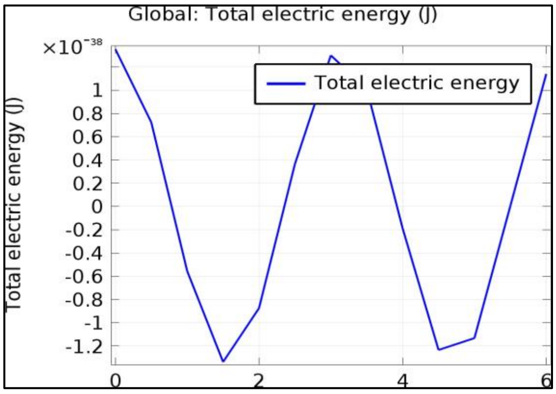

Figure 5:Displacement (nm) vs. Electric potential (V) curve showing an actuation

Modal Analysis or Eigen frequency analysis refers to the calculation of natural frequencies of vibration of the beam. Modal analysis is the study of the dynamic properties of structures under vibrational excitation. The Eigen values are used to determine the natural frequencies or Eigen frequencies of vibration, and the eigenvectors determine the shapes of these vibrational modes. Modal Analysis aids in computing the values of these mechanical resonant frequencies of vibration of the beam. FEM simulations employing COMSOL Multiphysics provides the deformed shapes of the beam when subjected to the various modes of vibration.

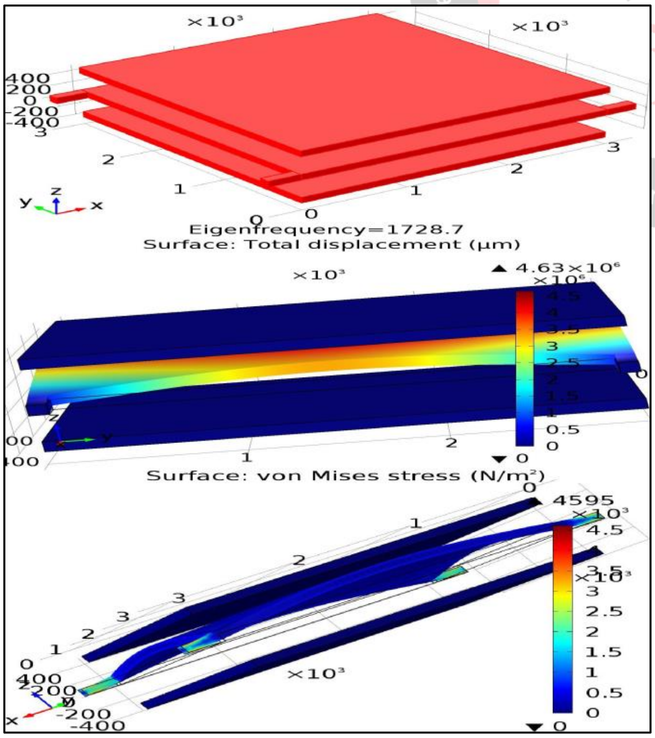

Figure 6: actual and deformed shapes of the miniaturized beam when subjected to the fundamental and higher order vibrational modes.

Figures 6 shows deformed shapes of the miniaturized beam when subjected to the fundamental and higher order vibrational modes. It is seen that deformed shapes are obtained corresponding to a higher order harmonic of the fundamental frequency of vibration

In order to perform accurate Modal Analysis in COMSOL Multiphysics, the various application modules used are-

MEMS Module

Structural Mechanics Solid,Stress-Strain

Static Analysis

COMSOL Multiphysics

Deformed Mesh

Moving Mesh (ALE)

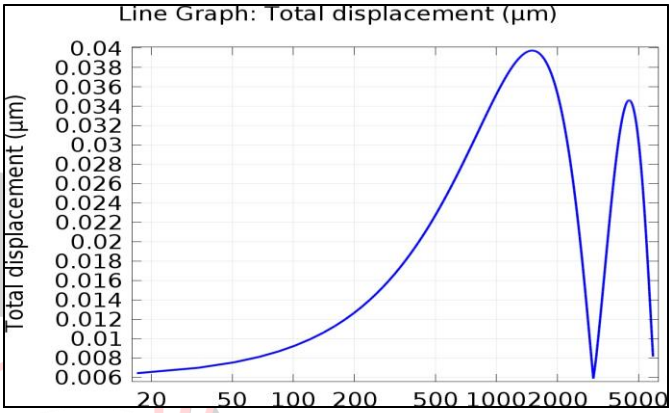

Figure 7:Eigen Frequency vs displacement

Figure 7 shows Eigen frequency versus displacement curve. Displacement vs eigen frequency plot in conventional structure, it is observed that as applied frequency increases, displacement also increases more displacement is observed

V. CONCLUSION

As the solution in current status are associated with the physical examination by the medical practitioner, challenges like severity and intensity and more time dependent aspects of tremor are not well approached. So alternative approach is develop the device that can detect the tremor which is associated with different disorders. A miniature sensors that can detect the tremor frequency which is very low in component was approached by the use of Micro Electro Mechanical System technology. Using this monitoring of the device can be approached either for self care as well integrating with IoT platform that can feasible for medical practitioner assessment in real time.The component is developed with the use of established Micro machining the process. cost effective.Overall cost of the device will be less than of the ten thousands. This work would certainly helpful for the people of aged where about 35-40% are above 60 years and above. This would be helpful in monitoring the tremor severity in the people having neurological disorders in self diagnosing the condition of them.

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