Three axial Accelerometer for Vibration Analysis

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ABSTRACT

Three axis Vibration measurement means the vibration response of an object subjected to high or low frequencies. Motion measurement means detecting the velocity or the displacement of the object in question. Other factor to consider include special requirement such as specific measurement conditions, environment, regulations and standards with which the accelerometer must comply. A broad spectrum of accelerometer which respond to the varying needs and application within motion and vibration measurement.

This adaptability is evident in the range of accelerometers designed for specific environments, industries tasks and condition, as well as general purpose instrument that provide a wide operational range. The main type of 3-axis accelerometer is Piezoelectric, IEPE, Piezoresistive, Variable capacitance accelerometer. The present study describes the development of a tri axial accelerometer (TA) and a portable data processing unit for the assessment of daily physical activity. The TA is composed of three orthogonally mounted uni axial Piezoresistive accelerometers.

This paper is to discuss the numerical modeling of 3D structure of micro-electro-mechanical systems (MEMS) accelerometers. The general idea being discussed is the method of levitation force reduction, as the main source of incorrect mathematical model of comb drive structure.

I.INTRODUCTION

1.Need :-The quantitative assessment of daily physical activity in humans requires an objective and reliable technique to be used under free-living conditions. From a physiological pointof view, physical activity can be regarded as any movement or posture that is produced by skeletal muscles and resultsin energy expenditure [1]. Currently, the energy expendituredue to physical activity is widely accepted as the standardreference for physical activity [2], but measurement of thisvariable under conditions of daily living is impractical and not feasible for population studies.

Therefore, the interestfor estimates of energy expenditure based on observations,questionnaires, heart rate recordings, or movement registration is growing. Electronic accelerometers are the most promising motionsensors for physical activity assessment in free-living subjects. These sensors respond to both frequency and intensity of movement, and in this way are superior to pedometers and actometers, which are attenuated by impact or tilt and only count body movement if a certain threshold is passed. Due to the current state of art in integrated circuit technology there is also good opportunity to build very small and lightweight accelerometer systems that can be worn for days or even weeks.

2.Feed of application:-The capacitive accelerometer consists of the moving comb teeth, suspended by spring beams on both sides, and fixed teeth. The suspension is designed to be in the x-direction of motion and to be stiff in the orthogonal direction (y) to keep the comb fingers aligned. Owing to phenomena complexity only field models are fully acceptable in 3D structure designing.

Providing intelligent functions for fabrics has often been reported in the field of wearable computing. In early studies, in order to realize functionality, several middle-sized sensors were attached on fabrics or clothes. Recently, it is getting easier to embed a large number of down-sized and low-cost sensors in elastic cloth-like materials, due to the recent advances in CMOS-MEMS and the new sensor networking technology.

In this paper, we discuss one of the realization methods of the 3DCS.shows the structure of the 3DCS. A clothlike sheet has a lattice structure on it. A triaxial accelerometeris attached on each link, and measures the gravity vector. Theposture of the link is calculated using the measured gravity.After the postures of all the links are obtained, the wholeshape of the sheet is computed by combining the links.[ref 1&2]

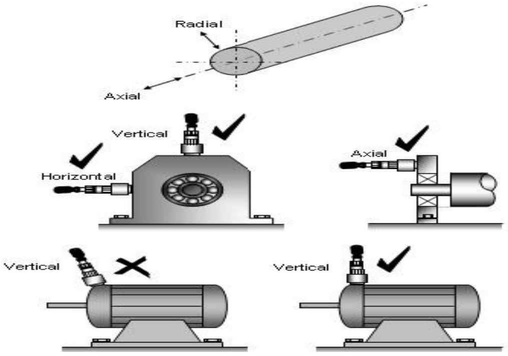

Fig Basic Measurement of Vibration By Accelerometer

II. PRINCIPLE WORKING OF TRIAXIAL ACCELEROMETER

When choosing an appropriate accelerometer for the assessment of daily physical activity one should consider the specifications of the various available electronic accelerometers as well as the characteristics of human movement which determine the output of a body-fixed

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accelerometer. These aspects are described below.Acceleromater are mainly works on the basis of piezoelectric or piezoresistive phenomenon.The Triaxial AccelerometerAn accurate registration of the frequencies and amplitudes Of accelerations involved in human movement is dependent on the type of accelerometer used. As is mentioned above, Piezoresistive accelerometers yield a dc response, whereas

Piezo-electric accelerometers do not. A major advantage of dc response is that it enables the calibration of piezoresistive Accelerometers, for instance by rotation within the Gravitational field. Human movement, however, will never Correspond to a dc response. Therefore, it was decided to use a piezoresistive sensor in combination with a high pass Filter to eliminate any resulting dc component during the registration of human movement, while retaining a very low frequency cutoff (about 0.1 Hz). A number of different uniaxial piezoresistive accelerometers was investigated and a small, lightweight accelerometer (ICSensors, type 3031-010, size:

4 4 3 mm; weight 0.3 g; range: 10 g, frequency response: 0–600 Hz; : 1200 Hz) was selected for further research. Three uniaxial accelerometers (A, A, and A) were mounted orthogonally onto a 12 12 12-mm cube made of Celeron to accomplish a TA with independent measurement directions.[ref 2]

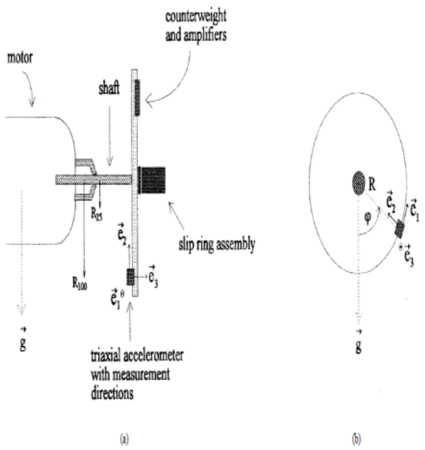

Fig.Experimental setup of Tri axial Accelerometer

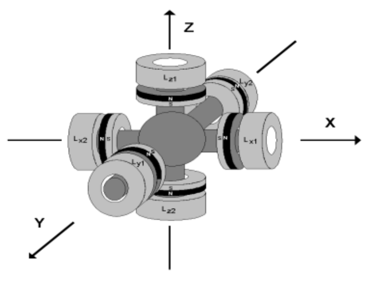

Fig.Working Phenomenon of Tri axial Accelerometer

In order to assess the usefulness of the TA for the measurement of accelerations involved in human movement, the device was tested in a laboratory experiment. The output of the three uniaxial accelerometers A, A, and A as a consequence of a mechanically applied acceleration was studied under various conditions. Interinstrument and test–retest comparisons weremade to test whether the outputs of A, A, and A were similar under the same experimental conditions and remained constant on different occasions.[ref 3]

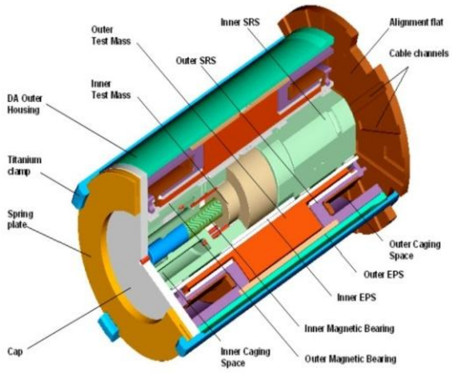

Fig.Construction of Tri-Axial Accelerometer

A capacitive sensing configuration, as shown in Figure 2.3, was chosen for the accelerometer because it gives high sensitivity with low temperature drift [4]. The device dimensions optimize large sensitivity over layout area and its functionality was verified using ANSYS. For the analog read-out circuit design, switched capacitor circuits were chosen to simplify the interface between the analog and the digital parts. All the analog circuit designs were simulated withHSPICE and laid out using Mentor Graphics software.[ref 2]

III. TYPES OF TRI-AXIAL ACCELEROMETER

Piezoelectric Accelerometers

Piezoelectric accelerometers use a spring mass system to generate force equivalent to the amplitude and frequency of vibration. The force is applied to a piezometricelement, which produces a charge on its terminals that is proportional to vibratory motion.

The unique design of piezoelectric accelerometer suitable for general purposes their exceptional high frequency characteristics are also ideal for high frequency vibration measurement application, such as gear noise analysis and monitoring of turbine or high speed rotating machinery.

Piezoelectric materials are self-generating , therefore ,do not require an external power source. They are capable of operating at extreme temperatures, but are constrained by low output sensitivity (inherent in any spring mass transducer design). Because most high frequency accelerometers are un damped, high frequency harmonics from structure can cause ringing of accelerometer & overload conditions in downstream electronics. The resonance frequency of the accelerometer should, therefore, be sufficiently high that it says above the high frequency signals that are present in the structure.

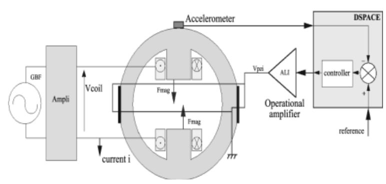

Fig.Piezoelectric Accelerometers

IEPE Accelerometer

IEPE accelerometers are piezoelectric accelerometer with integral pre amplifier, which give output signals in the form of voltage modulation on power supply line. IEPE

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accelerometer are specifically aimed at measuring vibration on small structures (for e.g., miniatures). There high output sensitivity, high signal-to-noise ratio and wide bandwidth make them suitable for both general purpose and high-frequency vibration measurements.

These low-cost and light weight accelerometers are high performance instrument that have higher output sensitivity than standard piezoelectric accelerometer (without integral amplifier). They are hermetically sealed to protect against environmental contamination, have love susceptibility to radio frequency electromagnetic radiation and low impedance output due to the external constant current power source.

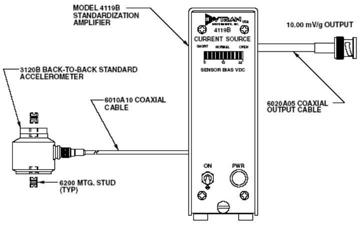

Figure 1: Model 3120BK system

Fig.IEPEAccelerometer

Pizoresitive Accelerometer

Pizoresitiveaccelerometers can be considered as damped mass-spring systems, in which aPizoresitive element acts as spring and damper. This element generates an electrical charge in response to the mechanical force, and hence, the acceleration applied to it by a small mass. In piezoresistive accelerometers "spring and damper" are replaced by silicon resistors which change electrical resistance in response to the applied mechanical load. The resistors are electrically connected in a Wheatstone bridge to produce a voltage proportional to the amplitude and frequency of the acceleration of the small mass in the sensor. Piezoresistive accelerometers are smaller than piezo-electric accelerometers,

But require an external power source. Furthermore, piezoresistive accelerometers have dc response, while piezo-electric accelerometers do not respond to constant acceleration.

However, no drift in sensitivity was observed during the laboratory experiments. From calibration data before and after the activity protocol in the respiration chamber, it was concluded that sensitivity and offset did also not drift during these long-term measurements.

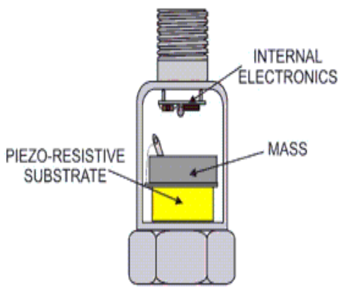

Fig.Piezoresitive Accelerometer

Variable Capacitance Accelerometer

In variable capacitance accelerometers, a unique variable capacitance microsensor forms a parallel plate capacitive device. The result is a sensor that provides response to DC acceleration inputs, stable damping characteristics that maximize frequency, and ruggedness to with stand extremely high shock and acceleration loads. These low-g accelerometers are perfect for measuring motion & low frequency vibration and are intended for application such as trajectory monitoring, air-craft, vehicle structural evaluation, flutter testing, automotive suspensions and brake testing.

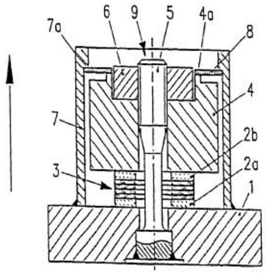

Fig.Variable Capacitance Accelerometer

MEMS Accelerometer

The system measures the acceleration of hand movements which are converted into two-dimensional location coordinates. The system consists of four major components MEMSaccelerometers operational block diagram of the mouse system.When a user moves the mouse in an arbitrary direction, theacceleration is decomposed into *X*- and *Y*-axis acceleration componentsby a corresponding "MEMS accelerometer". The actual accelerationvalue is represented by a differential capacitance betweentwo capacitors in the MEMS device. This capacitance value is simultaneously fed back to reset the MEMS device—so the nextacceleration can be measured without any bias—and fed forward.

Typically, there are three different types of MEMS accelerometers, piezo-resistive, tunneling, and capacitive. The capacitive accelerometer was chosen for this system because it provides high sensitivity, good DC response, low drift, low temperature sensitivity, low-power dissipation, and a simple structure. S.O.G technology was chosen for the implementation, instead of some other technology, to take advantage of its robustness and simplicity of design.[ref 5]

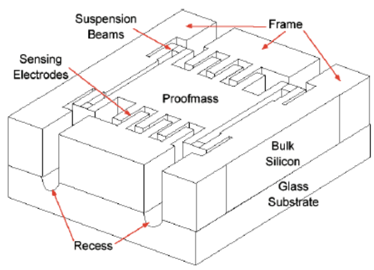

Fig.MEMSAccelerometer

IV. ACCELEROMETER FOR MOBILILE ROBOTE POSITIONIG

Introduction:-

Positioning technology could broadly divided in to two main stream :relativepositionig and absolute positioning. This type of mobile posioningaccerometer as an aanalogus device. Which is mainly used in the posionig system. It can be measure both dynamic as well as static acceleration. This accelerometer selected for evaluation as distance measuring

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sensor due to its small size, low cost and acceptable performance.

An accelerometer as a self-contained device. The accelerometer was moved back and four three times for a any type of distance. Accelerometer for mobililerobotepositionig is the system in which mainly robot is used. This system consist of robot arm,a controller, panel and PC for programing the robot arm. The duty cycle of accelerometer output is proportional to acceleration. The microcntroller used to measure the duty cycle using the timer system. Accelerometer for mobililerobotepositionig is the system in which microcontroller is the main basic part of anmobililerobotepositionig Accelerometer.Distance per step depends on the speed and the height of user. The step length would be longer if the user is taller or running at higher speed. The reference design updates the distance, speed, and calories parameter every two seconds. So, we use the steps counted in every two seconds to judge the current stride length.

KALMAN Filter

KALMAN Filter is comonly used method for random noise reduction and datd fusion for positioning application. In this method, statistical characteristics of a measurment model is used to recursively estimate the required data. A brif introduction of KALMAN Filter.[ref 3&6]

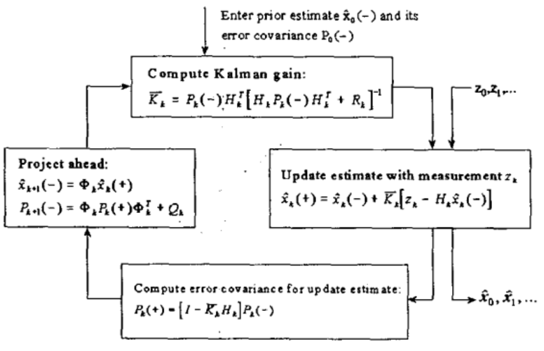

Fig.Flow Chart of KALMAN Filter

Notation:

Xk-System state.

Zk-Measurement

Wk-Plant noise with covariance Qk.

Vk-Measurment noise with covariance Rk.

(-)-Priori values of measurement.

(+) Posteriori value of measurement.

K-Kalman gain.

Qk-Transion matrix at tiome tk.

Pk-Error covariance matrix.
Hk-measorement matrix.

3-D COMB DRIVE ELECROSTATIC ACCELEROMETER

Micro Accelerometer 3d Structure

The base method of the proposed strategy is solid modeling. It is rapidly emerging as a central area of research and development in such diverse applications as engineering and product design, computer-aided manufacturing, electronic typing, etc. The solid model, which contains the external surfaces, edges and internal volume information, could be used for design representation, verification, simulation, analysis for processing, manufacturability and costing, and for both rapid prototyping and rapid tooling.

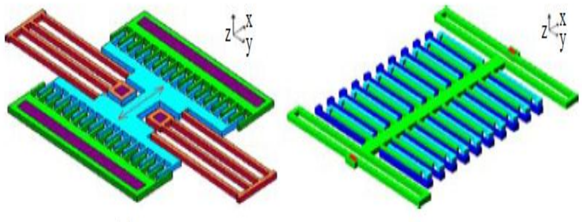

Fig.Micro Accelerometer 3D Structure

When the plates of the capacitor move towards each other, the work done by the attractive force between them can be computed as the change in W (stored energy) versus displacement (x). Levitation force exists in polysilicon comb drives because of the ground plane under the comb fingers. Comb fingers with a Si ground layer can generate vertical electrostatic force and have been used for vertical actuation. A lateral-axis comb drive. The Si layer is grounded. When a voltage is applied as shown in the z-axis force as well as the x-axis force is generated.

Modeling by Object Oriented Method

Simulation is a very important method to gain insight in complex systems, to make virtual experiments to get deeper understanding, and to verify new designs (Schwarz et al., 2004). Modelling, simulation and analysis tools are needed to support the MEMS designer during these activities. In the design of Microsystems, sophisticated CAD systems based on FEM, like OPERA from Vector Fields, COSMOS and ANSYS are exploited for modeling and simulation the behavior of the system components with high accuracy. Finite element analyses are the most commonly used methods for numerical mechanical and electrostatic simulations. These methods are accurate for fine meshes. However, as they are layout-based, any change to the geometric sizes requires a new mesh, leading to inconvenient design iteration (Jing et al., 2002) Unfortunately, FEM simulations are time consuming.

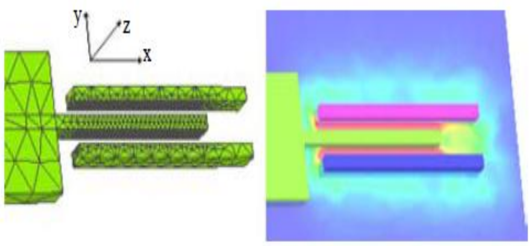

Fig.ModelingBy Object Oriented Method

In this work, the authors were introduced FEMs combined with object oriented methods in Matlab/Simulink. This strategy enable changes the all parameters of the comb drive. On the other hand, this strategy allowed totake advantage of FEM, what is a possibility calculation of

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complicated geometries without additional operations.[ref 5&8]

DISTRIBUTED TRIAXIAL ACCELEROMETERS

Effect of Noise On Acceleration Data

Preliminary evaluation of the TA and data processing unit was performed in a group of 13 young male subjects (age: 27 4 yr, body mass: 77 12 kg, height: 1.83 0.07 m) during a standardized long-term activity protocol in a respiration chamber [33]. This chamber (14 m) is furnished with abed, table, chair, toilet, washing-bowl, radio, and television and is provided with equipment for the determination of metabolic energy expenditure from respiratory gas exchange. The ventilation rate through the chamber was measured with a dry-gas meter (Schlumberger, G4) and analyzed by a paramagnetic O analyzer (Hartmann & Braun, Mangos 6G) and an infrared CO analyzer (Hartmann & Braun, Uras 3G). Ingoing air was analyzed once every 15 min and outgoing air twice every 5 min. From the ventilation rate and O and CO concentrations in in- and out-going air, O consumption and CO production were calculated on-line on a computer. Total energy expenditure was calculated at 5-min intervals from O consumption and CO production, according to Weir [34]. The subjects stayed in the chamber for 36 h: two nights and the intervening day. During day-time (0830–2200) they performed standardized activities, resembling normal daily activities (sedentary activities, household activities, walking). Each activity was performed for 30 min. Except for stepping and carrying loads, the activities were performed at the subjects' preferred rate. Stepping was performed at 5-min intervals, alternately with 5-min rest periods, on a bench 33 cm high and at a rate of 30 steps min or 60 steps min.

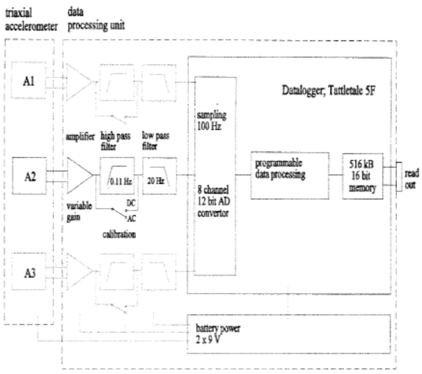

Fig.6.1.1 Block Diagram Distributed Tri axial Accelerometers

The Data Processing Unit

The block diagram shows the processing of the output from the TA, which is implemented in the data unit. The connection between the data unit and the TA is established via a 0.5 m flexible 12 conductor shielded cable. Individual outputs from the three measurement directions of the TA are amplified and high pass (0.11 Hz, 5.6 dB/octave) and low pass (20 Hz, 9 dB/octave) filtered to attenuate dc-response and frequencies that cannot be expected to arise from voluntary human movement.

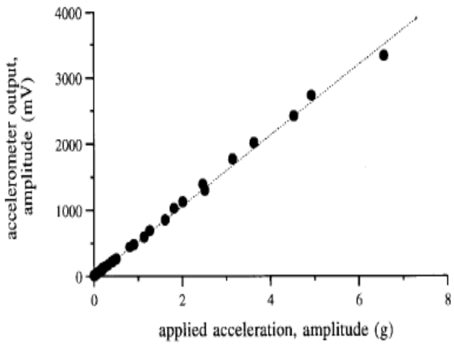

Fig.Graph of Data Processing Unit

This housing can be opened by the investigator for replacement of batteries and calibration of the accelerometers. The ac/dc switches within the housing are used to omit the high pass filters. The dc responses of the uniaxial accelerometers can than be applied to determine their sensitivity by altering the orientation of the TA with respect to the gravitational vector of the earth.[ref 2&7]

Advantages-

1) These types of instruments are used in the measurement of vibration of machine, machine element in the industry.
2) The tri axial accelerometer are use to measure the vibration, motion, displacement of machine components in X, Y, Z direction.
3) Tri-axial accelerometer gives efficiency of machine which is used in industry.
4) Accelerometers used for the assessment of physical activityin humans must provide accurate registrations of thefrequencies and amplitudes of accelerations involved in humanmovement.
5) Tri axial accelerometer is used in MEMS technology.

Disadvantages-

1) An output from trials performed at the same angular velocity but at different radii was taken to eliminate and to determine the sensitivity due to the radial acceleration.
2) Accelerations with frequencies above 10 Hz were not included in the experiments. It was assumed, however, that frequencies within the range of human body movement (up to 20 Hz) could be measured accurately with the uniaxial accelerometers which have a frequency response of 0–600 Hz. To verify this assumption, one of the uniaxial accelerometers (A) was tested using a vibration excitatory.
3) The output of a single triaxial accelerometer contains only the information about the two angles. They used other types of sensors such as an electromagnetic compass or a gyro sensor to acquire the yaw angle. Unlike them, we used multi accelerometers to estimate the yaw angles without any other kinds of sensors.
4) Tri-axial accelerometers are highly in cost.
5) Highly skilled operator require for measurement of vibration.

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V. Application

1) The 3DCS has several potential applications. First, the device can be used in measuring the shape of 3D objects. The shape and size of an object can be measured easily by wrapping it with the 3DCS.
2) The human posture can also be measured by wearing it. Second, it is possible to make a soft tactile sensor with the 3DCS by covering compressible materials such as urethane foams with it. If the deformation of the surface of the material is given, the number, shapes, positions of the contact objects can be estimated.
3) There are several noise sources that affect the performance of the overall system; determining the minimum detectable input acceleration. In an oversampled electromechanical sigma-delta system.
4) The primary mechanical noise source for the device is due to the Brownian motion of gas molecules between comb fingers. The total noise equivalent acceleration.

VI. CONCLUTION

The development of a TA and portable data unit has resulted in a new accelerometer device for physical activityassessment. Major advantages of the device are the use ofpiezoresistive accelerometers, which facilitates calibration, theability to measure and analyze accelerations from three differentmeasurement directions, and the on-line data processingto quantify accelerometer output as a function. The vector field analysis (mechanical and electrical) has given the knowledge about thestructures of the micro accelerometer, as well as the dynamic behavior of the analyzedobject.On the base of this research a following conclusion could be drawn that: only the 3D design with the application of the solid modeling delivers the fullview of the phenomena occurring in the accelerometers; and such complex, object-oriented solution makes possible the full simulation ofdevice and optimization MEMS devices.

This paper proposed a new flexible sensing device"3DCS", which measures its own 3D configuration usingdistributed triaxial accelerometers. The details of the structure and the shape estimation algorithm are described. Itis shown that the proposed estimation algorithm works wellexcept for the trivial cases. The 2×2 prototype succeeded inestimating the shapes of a flat plate and a sphere with 7 %estimation error.In this paper, we presented a novel two-dimensional positiondetection system for pad less mouse applications that do not requireany contacts for proper mouse operation. The design requirementswere carefully examined and the systematic design methodology was established. The final system consists of four major components MEMS accelerometer each module was carefully designed, laid out, andverified through extensive simulation.

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