Measure angular motion of a memsbased gyroscope essay sample



The graduate students at GIKI have worked on the development of MEMSbased gyroscopes. For this purpose a rate table was required for the MEMS lab in order to test these gyroscopes. Hence this task was undertaken at undergraduate level in the form of a final year project. The purpose of this was to create technical awareness of MEMS technology at an undergraduate level plus achieve the required goal in a very cost effective manner. Problem Definition

The task was to indigenously develop a rate table which not only is costeffective but also delivers performance parameters. Aim The aim was to design a single-axis rate table. On the top of the rate table, IC (gyroscope) shall be mounted. From a PC through a controller, the rate table shall be rotated at the required rate (rpm). All the connections to the IC shall be available through the non-rotating base of the table. Time line

Date| Event|

Sep ' 08| * Project proposal * Collection of data * Analysis of Data * Project approval| Oct ' 08| * Understanding of Rate Tables * Initial Design of Rate Table| Nov ' 08| * Simulation results * Status report of Hardware & Software| Jan ' 09| * Design of Controller * Design of Rate Table| Feb ' 09| * Implementation of Hardware design * Integration of Hardware & Software| Mar ' 09| * Testing and Troubleshooting|

Apr '09| * Open House * Final Report and Thesis|

Milestones with task break

Milestones | Responsibilities |

* Project proposal * Collection of data * Analysis of Data * Project approval| * https://assignbuster.com/measure-angular-motion-of-a-mems-basedgyroscope-essay-sample/ All * Usman & Sarah * Saad & Nabeel * All| * Understanding of Rate Tables * Initial Design of Rate Table| * Usman & Nabeel * Saad & Sarah| * Simulation results * Status report of Hardware & Software| * Usman & Saad * Nabeel & Sarah| * Design of Controller * Design of Rate Table| * Saad & Nabeel * Usman & Sarah| * Implementation of Hardware design * Integration of Hardware & Software| * All * All| * Testing and Troubleshooting| * All|

* Open House * Final Report and Thesis | * All * All

Chapter 2

Introduction to Rate Table

Rate table is a device which is widely used for testing and calibrating instruments such as precision gyros and accelerometers which comprise the basic sensors in high-accuracy inertial guidance systems. Because these sensing instruments are capable of measuring extremely minute dynamic quantities, formidable demands are placed on the rate tables used for supplying known inputs to these instruments. Thus, to be compatible with the accuracy of gyros and accelerometers currently in use, a rate table system must be capable of measuring and controlling angular velocities down to the order of 0. 001 degree per second. Single-Axis test tables provide precise angular position, rate and acceleration for development and production testing of inertial components and systems. What is Gyroscope?

Micro machined inertial sensors, consisting of accelerometers and gyroscopes are one of the most important types of silicon based sensors. A gyroscope is a device for measuring or maintaining orientation, based on the principles of angular momentum. The Gyroscope developed at GIKI is a thermally actuated 3-DoF micromachined gyroscope utilizing Chevron thermal actuators to drive proof mass. There are a number of actuation mechanisms which include electrostatic, piezoelectric, thermal etc. The benefits of this design will be described later.

These actuators are activated by Joule heating. When a potential difference is applied between two or more points on electrically conducting material it causes flow of electrical current which induces thermal strain due to internal heating. Consequently these thermal strains generate the desired mechanical deformation or force. These thermal actuators are capable of providing a large force.

There are two types of thermal actuators: hot/cold arm thermal actuators and 'V' or Chevron' shaped actuators.

The displacement in Chevron actuators is proportional toV2.

Mass m1 is constrained to oscillate only in the drive direction (1-DOF) whereas the mass m2 is free to oscillate in both drive (X-axis) and sense (Yaxis) direction (2-DOF). This makes the system a 3-DOF one. Mass m1 is excited in the drive direction. When the system is rotated a Coriolis force acts on mass m2 which can be measured using capacitance changes. This information in turn can be used to determine the rotation or orientation of the system.

Advantages of this design:

High force, large displacement and low voltage consumption are the primary

concerns for micro-gyroscopes. In comb drive actuators, a p. d. of 20V https://assignbuster.com/measure-angular-motion-of-a-mems-based-gyroscope-essay-sample/

causes a displacement of 5μ m whereas in Chevron based thermal actuators a p. d. of only 0. 1V causes a displacement of 5. 5μ m.

Gyroscope Testing:

* In gyroscope testing we stimulate the gyroscope by mounting it on the rate table. * Rate table provides the gyroscope precise angular motion about one or several axis. * This angular motion causes capacitance changes in the gyroscope. * This capacitance change will be used to measure rotation and orientation Commercially available Rate Table

Rate tables are designed to provide precise position, rate and acceleration motion for development or production testing. This test instrument is used for the testing and calibration of sensors and gyroscopic instruments which require a precise and accurate angular velocity. During the study we came across the vendors of the testing equipment. Ideal Aerosmith, EVO-10 and Acutronic are the market leaders.

Below are stated generic specifications of a few rate tables.

PHYSICAL CONFIGURATION AND SPECIFICATION

Ideal Aerosmith

Specifications| 1291BR| 1270VS| 1280T|

Table top surface characteristics * Diameter * Material| 8inchesAluminum| 12 inchesAluminum| 14 inchesAluminum| Controller * Type * Comm. Interface * Speed| InternalRS-232 19200 baud| RS-2329600 baud| AERO 800 Test Table ControllerRS-232 standard,| Power requirements| Standard 115 VAC,

50/60HzOptional 230 VAC, 50/60Hz| 115 VAC, 50/60 Hz Standard (230

VACoptional)| Standard: 115 VAC, 50/60 Hz Optional: 230 VAC, 50/60Hz| https://assignbuster.com/measure-angular-motion-of-a-mems-based-gyroscope-essay-sample/

Drive type| DC torque motor with servo controlled system| DC Servo Motor| Direct-drive, DC brush-type servo system| Operating Environment| 50 to 95° F (10 to 35° C)20% to 85% non-condensing| 32° to 130° F (0° to 54° C), 20% to 85% non-condensing| 50 to 95° F (10 to 35° C), relative humidity 20% to 85% non-condensing| Slip ring package| Standard: 34 lines Optional: 66 lines | Standard: 16 linesOptional: 22, 28, or 66 lines| 48 lines|

PHYSICAL CONFIGURATION AND SPECIFICATION

EVO-10|

Specifications| EVO-10S| EVO-10| EVO-10M| EVO-10L|

Tabletop Diameter| 300mm| 300mm| 300mm| 300mm| Drive mechanism| Direct/brushless motor|

Slip rings| 34 lines| 34 lines| 34 lines| 34 lines| Controller| Small controller

unit| Modular control unit with modular power unit| Comm. Interface| |

RS232, Ethernet

PHYSICAL CONFIGURATION AND SPECIFICATION

ACUTRONIC|

Specifications| AC1125| AC-DC130| AC 1135|

DimensionsDiameter| 500 mm| 16 inches| |

Slip Rings| 30 lines| 30 lines| 30 lines|

Drive System| Brushless AC motors| High torque direct drive brushless servo

motors| Brushless torque motor| Controller| ACT3000 series| ACUTROL3000-

PA or ACUTROL3000| ACUTROL ACT 3000 |

Comm. Interface| RS232, Ethernet |

Chapter 3

Design

Hardware

The hardware requirement for the fabrication of the rate table is: * Motor

- * Gyroscope IC
- * DC power supply
- * Slip rings
- * Controller
- * RS 232 Interface
- * Lathe Machine
- * Shaper Machine
- * Personal Computer (PC)
- * Micromachining Device

Motor

A brushless DC motor (BLDC) is a synchronous electric motor which is powered by direct-current electricity (DC) and which has an electronically controlled commutation system, instead of a mechanical commutation system based on brushes. In such motors, current and torque, voltage and rpm are linearly related. BLDC motors are considered to be more efficient than brushed DC motors. BLDC motors offer several advantages over brushed DC motors this includes higher efficiency and reliability, reduced noise, longer lifetime (no brush erosion), elimination of ionizing sparks from the commutator, and overall reduction of electromagnetic interference (EMI). Comparison of conventional and brushless DC motors:

Page 8

| Conventional motors| Brushless motors|

Mechanical structure| Field magnets on the stator| Field magnets on the rotor. Similar to AC synchronous motor| Distinctive features| Quick response and excellent controllability | Long lasting and easy maintenance | Winding connections| Ring connections. The simplest Δ connection.| Δ or Y connections| Commutation method | Mechanical contact between brushes and commutators. | Electronic switching through transistor| Detecting method of rotor's position | Automatically detected by brushes| Hall element, optical encoder| Reversing method| By a reverse of terminal| Rearranging logic sequencer|

The motor used in the Rate Table is a brushless DC motor and driver package with digital operator. It is a product of Oriental Motors. It is the BLF series with the model number BLF 460C-200.

Specifications:

Model BLF460C-□Combination Type – Parallel Shaft Gear head| Rated Output Power (Continuous) W (HP)| 60 (1/12)| Rated voltage V| Single-Phase 200– 240 _10%| Rated frequency Hz| 50/60 _5%| Rated input current A| 1. 2| Maximum input current A| 3. 0| Rated Torque N_ m (oz-in)| 0. 2 (28. 4)| Starting torque N_ m (oz-in)| 0. 4 (56. 8)| Rated speed r/min| 3000| Speed control range r/min| 80_4000|

Slip Rings

A slip ring is an electromechanical device that allows the transmission of power and electrical signals from a stationary to a rotating structure. Also called a rotary electrical joint, collector or electric swivel, a slip ring can be used in any electromechanical system that requires un-restrained, intermittent or continuous rotation while transmitting power and/or data. It can improve mechanical performance, simplify system operation and eliminate damage-prone wires dangling from movable joints. The slip ring used in the Rate Table is by MOOG Inc., model no. AC 6355- 36. The specification and the diagram for the slip rings are stated below. Operating Speed| 250 rpm|

Circuit Configurations 36 ring 36 @ 2 amp 4 @ 5 amp; 28 @ 2 amp 4 @ 10 amp; 20 @ 2 amp 4 Lead Length 24 inch (600 mm)

Voltage 210 VDC

Operating Temp.| -40°C to +80°C|

Contact Material| Gold-on-gold signal; gold-on-gold power| Housing| Plastic| Lead Size/ Type| 2 amp, 26 AWG5 amp, 20 AWG10 amp, 16 AWG| Dielectric Strength| 250 VAC @ 60 Hz, between each circuit and all other circuits| Insulation Resistance| 1000 mega ohms max tested @ 500 VDC| Electrical Noise| 60 milliohms max when tested @ 6VDC50 milliamps when running @ 10 rpm|

Mercotac

Mercotac are mercury-based electrical connectors superior to slip rings. The electrical conduction path is a liquid metal that is molecularly bonded to the contacts. This creates a connection that is constant and unchanged for the life of the connector. Mercotac connectors are maintenance free, do not degrade the signal over time and last much longer than slip rings. They transmit with near zero electrical noise, thus the same connector can be

used for power and signal transmission.

https://assignbuster.com/measure-angular-motion-of-a-mems-basedgyroscope-essay-sample/ Amongst the various models available, the most appropriate one that seemed for the Rate Table was Model 830. Below are the specifications and diagram for the model.

Model No.| Conductors| Description| Voltage AC/DC| Max. Freq. MHz| Contact Resistance| Max OP. RPM| AMP Ratingat 240 VAC| TemperatureMax. F (C) / Min. F (C)| RotationTorque (gm-cm)| 830| 8| Standard Model| 0-250| 100| <1m| 200|/| 140(60)/-20(-29)| 1000| 830 SS| 8| Stainless Steel Bearing| 0-250| 100| <1m| 200|/| 140(60)/-20(-29)| 1000|

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