Micromachined Gyroscope Design Allowing for Both Robust Wide-Bandwidth and Precision Mode-Matched Operation

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BRIEF DESCRIPTION

University researchers have designed a new z-axis gyroscope design with a 2-DOF sense mode allowing interchangeable operation in either precision (mode-matched) or robust (wide-bandwidth) modes. This is accomplished using a complete 2-DOF coupled system which, unlike the previous multi-DOF design, allows for the specification of the sense mode resonant frequencies and coupling independent of frequency.

FULL DESCRIPTION

The robust mode corresponds to operation between the 2-DOF sense mode resonant frequencies providing a response gain and bandwidth controlled by frequency spacing. Precision mode of operation, however, relies on mode matching the drive to the second, anti-phase sense mode resonant frequency which can be designed to provide a gain advantage over a similar 1-DOF system. Experimental rate characterization of an SOI prototype in air for both robust and precision modes revealed scale factors of 0.282 and 0.690 mV/deg/s respectively. The improvement due to precision mode operation is increased to 27 times for operation in 500 mTorr reduced pressure.

SUGGESTED USES

- Camera stabilization;
- Personal navigation;
- GPS augmentation;
- Automotive electronic stability control

BACKGROUND

Micromachined vibratory gyroscopes operate based on the Coriolis effect where a rotation induced energy transfer occurs between two orthogonal vibrational modes, commonly referred to as drive and sense. Conventionally, these modes are realized as single degree of freedom (DOF) dynamic systems with their own associated resonant frequencies giving rise to two differing methods of operation: mode-matched or mismatched. In mode-matched devices, the drive and sense resonant frequencies are equal allowing the output of the sensor to be increased proportional to the sense mode quality factor yielding higher sensitivities at the cost of reduced bandwidth and robustness. Operation with the resonant frequencies separated by some prescribed amount, or mode-mismatched, is more common, particularly for automotive applications where robustness is critical.

Gyroscope design concepts have been introduced aimed at robust operation using an expanded sense mode design space through increased degrees of freedom. Specifically, the device used two coupled sense masses forming a 2-DOF dynamic system with two sense mode resonant frequencies and a wide region of constant amplitude between them. While the gain and the bandwidth of this operational region is controlled solely by

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OTHER INFORMATION

KEYWORDS

gyroscope, z-axis

CATEGORIZED AS

- **Engineering**
  - Engineering
- **Sensors & Instrumentation**
  - Analytical
  - Environmental Sensors
  - Other
  - Position sensors

the resonant frequency spacing, a constraint limited the minimal achievable spacing as the operational frequency of these devices with fixed size was increased. This is a direct effect of the dynamic vibration absorber type 2-DOF design which utilized only two suspensions thereby eliminating the ability to independently define the frequency spacing and the coupling between the masses. In contrast, a complete 2-DOF system consisting of two masses and three suspensions alleviates this issue allowing for the arbitrary specification of frequency spacing independent of operational frequency.

» **Transportation**

» Automotive

RELATED CASES

2009-547-0

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	9,310,199	04/12/2016	2009-547
United States Of America	Issued Patent	8,800,370	08/12/2014	2009-547
United States Of America	Issued Patent	8,549,915	10/08/2013	2009-547

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- 3-D Folded MEMS Technology For Multi-Axis Sensor Systems
- Prioritizable IMU Array (Prio-IMU) for Enhanced Pedestrian Navigation
- Micro-glassblowing for Gyroscope Fabrication

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