Temperature-Robust MEMS Gyroscope with 2-DOF Sense-Mode Addressing the Tradeoff Between Bandwidth and Gain

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BRIEF DESCRIPTION

University researchers have designed a novel MEMS vibratory rate gyroscope design, which yields devices robust to fabrication and environmental variations, allows flexible selection of operational parameters, and provides increased bandwidth with minimized sacrifice in gain regardless of the selected frequency of operation.

FULL DESCRIPTION

The gyroscope has a single degree-of-freedom (DOF) drive-mode and a 2-DOF sense-mode. The design of the structure provides advantages over current gyroscope designs which were based on dynamic vibration absorber type of the 2-DOF sense-mode. The drive-mode operational frequency and the sense-mode bandwidth can be selected arbitrarily in the proposed design, relaxing the tradeoff between the gain, die size, and detection capacitance. The symmetry of the structure ensures the optimal location of the drive-mode resonance relative to the sense-mode operational region, even in presence of fabrication imperfections. Prototypes with 2.5 kHz operational frequency experimentally demonstrated up to 400 Hz 3 dB sense-mode bandwidth. The gyroscope's bias and the scale factor temperature coefficients were measured as 313 °/h/°C and 351 ppm/176;C, respectively.

The prototypes exhibited a rate sensitivity of 56 μV/°/s and a rate-equivalent uncompensated quadrature of 62.5 °/s. Using off-chip detection electronics, the experimentally measured resolution was 0.09 °/s/√Hz.

APPLICATIONS

Camera stabilization; personal navigation; GPS augmentation; automotive electronic stability control

BACKGROUND

The operation of all micro-machined vibratory gyroscopes is based on a transfer of energy between two modes of vibration caused by the Coriolis effect. Conventional implementations often utilize single degree of freedom drive and sense-modes. Various groups have reported gyroscopes with structurally symmetrical designs aimed at mode-matched operation. In such implementations, the mechanical gain is increased proportionally to the sense-mode quality factor. Also, mode-matching feedback control can be employed to improve sensitivity by automatically tuning the drive- and sense-modes. However, mode-matched operation has serious drawbacks, since the increased sensitivity is achieved at the cost of sensor robustness and bandwidth. Alternatively, the modes can be designed with a certain frequency mismatch. Even though this approach improves the robustness and the bandwidth, it does not provide the optimal solution because of the restricted design space. Limitations of the single-DOF mode design dictate a tradeoff between achieved robustness/bandwidth and gain.

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OTHER INFORMATION

CATEGORIZED AS

- **Nanotechnology**
  - Electronics
  - Other
- **Sensors & Instrumentation**
  - Other
  - Position sensors

RELATED CASES

2008-503-0

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	8,656,776	02/25/2014	2008-503
United States Of America	Issued Patent	8,443,667	05/21/2013	2008-503

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