# Fully Balanced Micro-Machined Inertial Sensor

Tech ID: 25656 / UC Case 2015-139-0

## BRIEF DESCRIPTION

· New balanced Coriolis vibratory gyroscope architecture

· Features:

o Force and torque balanced on both x and y modes

o Vibration immunity for gyroscope architecture

o High Q-factor on both modes

o Simple construction

o 1-2 orders of magnitude lower ARW or white noise output

## FULL DESCRIPTION

This invention is a new balanced Coriolis vibratory gyroscope architecture that is force and torque balanced on both x and y modes. In contrast to tuning fork Coriolis vibratory gyroscopes, which are torque balanced only on one axis, this architecture is torque balanced on both axes (modes). As a result, anchor losses are minimized on not only one but two axes. This helps achieve high Q-factor on both modes of the Coriolis Vibratory Gyroscope and provides vibration immunity due to the force/torque balance. The design has also been shown to produce 1-2 orders of magnitude less white noise of the gyroscope output (ARW) than current commercial competitors. The mechanical element of the gyroscope design is comprised of two proof masses that are mechanically coupled to each other. The gyroscope can be built using any two arbitrary shaped lumped masses, provided that their centers of mass approximately collide with each other.

RELEVANT BACKGROUND

A Coriolis vibratory gyroscope (CVG) is a type of inertial sensor that uses a vibrating object or resonator to detect changes in motion, utilizing the principle that a vibrating object tends to continue vibrating in the same plane as its support rotates. As an example, one type of CVG, known as the tuning fork gyroscope, utilizes a pair of masses driven to resonance. Displacement of these masses from the plane of oscillation is detected and measured relative to the rotation of the system. Quality-factor (Q-factor), which relates the energy stored to the energy loss over a period of the resonator, is an important parameter that should be maximized for optimal gyroscope performance. In short, a higher Q-factor translates to lower energy dissipation. In order to maximize Q-factor, energy loss mechanisms of the resonator must be addressed. An important loss mechanism, anchor losses, are caused by acoustic losses into the substrate and are not well minimized in a standard tuning fork gyroscope, as they are torque balanced on only one axis and hence anchor losses are minimized in only one mode of vibration. This new gyroscope architecture minimizes anchor losses in both axes by decoupling the resonator and the substrate by using a dynamically balanced resonator structure, leading to a more maximal Q-factor.

## SUGGESTED USES

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## OTHER INFORMATION

## CATEGORIZED AS

- **Engineering**
  - Engineering
  - Other
- **Sensors & Instrumentation**
  - Other
  - Physical Measurement
  - Position sensors

## RELATED CASES

2015-139-0

o MEMS inertial sensor for use in consumer electronics and a wide variety of other applications such as in the automotive and aerospace industries

## ADVANTAGES

· Device has high sensitivity and robustness to external vibrations. To the best of our knowledge this is the highest Q-factor degenerate mode gyroscope less than 2mmx2mm

· Force and torque balanced is established on all axes, as opposed to a single axis balanced architecture seen in prior art.

· Force and torque balance is obtained on all 3 degrees of freedom, providing immunity to vibrations along all axis.

· Compared to prior art, the device is extremely simple in construction, utilizes a single mask fabrication process, and only two primary proof masses, making fabrication of the gyroscope very cost effective.

· White noise of the gyro output is 1-2 orders of magnitude better than what is currently commercially available.

## PATENT STATUS

| Country | Type | Number | Dated | Case |
| --- | --- | --- | --- | --- |
| United States Of America | Issued Patent | 10,247,554 | 04/02/2019 | 2015-139 |

## OTHER INFORMATION

http:// mems.eng.uci.edu/files/2015/05/DorukSenkal_ISISS_2015.pdf

http:// mems.eng.uci.edu/files/2015/07/Senkal_Transducers_2015.pdf

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