

UC Berkeley

EE C247B - ME C218 Introduction to MEMS Design Spring 2018

Prof. Clark T.-C. Nguyen

Dept. of Electrical Engineering & Computer Sciences
University of California at Berkeley
Berkeley, CA 94720

Lecture Module 15: Gyros, Noise, & MDS

EE C245: Introduction to MEMS Design LecM 15 C. Nguyen 11/18/08 1

UC Berkeley

Lecture Outline

- Reading: Senturia, Chpt. 14, Chpt. 16, Chpt. 21
- Lecture Topics:
 - ↳ Gyroscopes
 - ↳ Gyro Circuit Modeling
 - ↳ Minimum Detectable Signal (MDS)
 - Noise
 - Angle Random Walk (ARW)

EE C245: Introduction to MEMS Design LecM 15 C. Nguyen 11/18/08 2

UC Berkeley

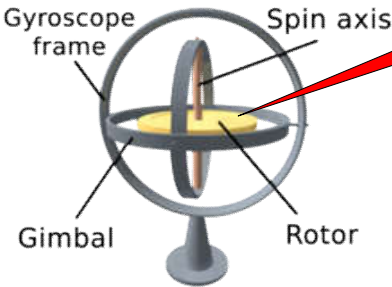
Gyroscopes

EE C245: Introduction to MEMS Design LecM 15 C. Nguyen 11/18/08 3

UC Berkeley


Classic Spinning Gyroscope

- A gyroscope measures rotation rate, which then gives orientation → very important, of course, for navigation
- Principle of operation based on conservation of momentum
- Example: classic spinning gyroscope



Gyroscope frame Spin axis
Gimbal Rotor

Rotor will preserve its angular momentum (i.e., will maintain its axis of spin) despite rotation of its gimballed chassis



EE C245: Introduction to MEMS Design LecM 15 C. Nguyen 11/18/08 4

Vibratory Gyroscopes

- Generate momentum by vibrating structures
- Again, conservation of momentum leads to mechanisms for measuring rotation rate and orientation
- **Example:** vibrating mass in a rotating frame

Mass at rest y' x'

Driven into vibration along the y -axis

$C(t)$

y -displaced mass

Capacitance between mass and frame = constant

Rotate 30°

Get an x' component of motion $C(t_2) > C(t_1)$

$C(t_1)$

$C(t_2)$

EE C245: Introduction to MEMS Design LecM 15 C. Nguyen 11/18/08 5

Basic Vibratory Gyroscope Operation

Principle of Operation

- Tuning Fork Gyroscope:

Input Rotation $\vec{\Omega}$

Driven Vibration @ f_0 \bar{v}

\bar{a}_c

Coriolis (Sense) Response

Coriolis Torque

z

y

x

EE C245: Introduction to MEMS Design LecM 15 C. Nguyen 11/18/08 6