Gyroscope Design Project

Issued Thursday, Nov. 13, 2008
Due Tuesday, Dec. 16, 2008 (tentative)

Objective:

This project aims to do the complete design, layout, and simulation, for a MEMS-based gyroscope satisfying a certain set of specifications with cost as an optimizing parameter.

Background:

Gyroscopes measure the rate of rotation of the object on which they are mounted. Rotation rate information, of course, is essential to navigation and without gyroscopes our planes and boats would have a very difficult time reaching their destinations. Beyond navigation, however, gyroscopes are now being used in numerous consumer applications, from skid control in automobiles, to inertial sensing in video game wands, e.g., the Wii. As with all consumer applications, cost is king, and this is the reason why MEMS-based gyros are the gyros of choice for almost all consumer applications.

This project aims to present a realistic design experience for a MEMS-based gyroscope and in the process elucidate how cost and performance can very strongly influence design.

Specifications:

For this project, you are to design a MEMS-based gyroscope using any MEMS technology that meets (or attempts to meet) the following specifications:

1) Angle random walk:	0.1 $^{o}/\sqrt{Hz}$
2) Bias drift over 0-70°C:	1 ^{o}/hr
3) Scale factor stability over 0-70°C:	0.1%
4) Full scale range:	500 ^{o}/s
5) Bandwidth:	1-100 Hz
6) Maximum MEMS chip area:	3 mm × 3 mm
7) Cost:	minimize

To meet the above specifications, you can assume that you have a sustaining amplifier circuit that can sustain the resonance oscillation of any device with a motional resistance less than 1 MΩ and resonance frequency less than 100 kHz. Assume also that this sustaining amplifier has an automatic level control circuit that can limit the amplitude of oscillation to any desired value. (Basically, this paragraph is stating that you need not design a sustaining amplifier.)

For all other electronics, e.g., for the sensing circuit, you will need to find suitable parts from appropriate vendors (using the web), then design circuits based on your chosen parts that satisfy the above gyroscope specifications. Hopefully, doing this search will teach you how easy it is to find the right electronic parts for this and your many future research projects.

Logistics:

You will work in groups of three. Try to form groups so that you have at least one member from a mechanical background and one from an electrical background.

Attached to this handout are some pieces of literature pertinent to the gyroscope project at hand. You are expected to do further literature investigation, using these as starting points. There will also be additional handouts concerning details of this project later.

The deliverable for this project will consist of:

1) A written report of no more than 10 pages in two-column format with figures (like an IEEE journal paper) detailing your design and simulation results. This report should include circuit schematics and tables summarizing performance. More detail on the weighting for specific topics (e.g., cost assessment, tables, specs) will be forthcoming in a separate handout.
2) A process traveler detailing the fabrication sequence used to construct the MEMS portion of your device.
3) A gds file containing your layout.

In addition to teaching technical design aspects, part of the intent of this project is to give you the experience of designing with others from disciplines very different from your own. You will likely find that this is not an easy thing to do, but that you can make it much easier if you can all speak the same technical language (e.g., using electromechanical analogies and equivalent circuits). You will also doubtless learn a great deal from those with different backgrounds.