

MEMS Inertial Rate and Acceleration Sensor

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ABSTRACT

Development of the μ SCIRAS™ (pronounced micro-Cyrus) multisensor for a period of over six years has produced a practical MEMS Inertial Measurement Unit (IMU). Using only three silicon sensors, a full-up IMU suitable for tactical grade navigation and guidance applications has been achieved. Iterative improvements in silicon sensor design and bulk micromachining processes have matured to the point where an IMU with an attractive price/performance ratio is now producible. This paper summarizes the design features and test results for an IMU with < 100 deg/hr performance. Test results are shown for rate bias and acceleration bias over temperature.

Production of this initial member of the μ SCIRAS product family begins this year to support applications including guided artillery shells, technology insertion to decrease missile costs, navigation of remotely-piloted vehicles, dismounted soldier location devices and other navigation aids. The small size of this silicon multisensor and its ability to measure both angular rotation rate and linear acceleration provides a useful advantage in product packaging, cost, size, and system testing. The μ SCIRAS Inertial Sensor Assembly (ISA) is housed in a 2 cubic inch

package weighing less than 5 ounces (140 grams) requires less than 0.8 Watts of power. Continuing development will lead to greatly improved performance on the order of 1 deg/hr at low prices in high-volume production.

INTRODUCTION

In the rapidly advancing world of Micro-Electro-Mechanical Sensors, or MEMS, there are many new design approaches used to achieve rate sensors. As sizes shrink, a new set of error sources come into play which ultimately set the limits of performance. Bulk micromachining offers the benefits of mass production, but not at the price of performance. By utilizing the full thickness of the silicon wafer, sensitivity to line width, mask alignment and flatness are greatly reduced. At the same time, the long term stability of the device is enhanced due to the low stress of the lightly doped layers. While bulk machined sensors are larger than surface machined, the cost to the user is minor due to the relatively higher costs of the electronics and packaging. Thus the performance is maximized without the need for mechanical or electrical trimming.

The development of μ SCIRAS is the culmination of six years of silicon work, and seven prior years of macro-size mechanisms. Leveraging off of the strength of three decades in the design of precision linear accelerometers, the rate sensor consists of two linear accelerometers etched within a unique dither mechanism. This produces a direct cost advantage in that both linear acceleration and angular rate are sensed by the same silicon and processing electronics. The dither drive mechanism was designed to not only provide a velocity

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