Micro-electro-mechanical-systems Rate Gyro—Extended Duration Testing

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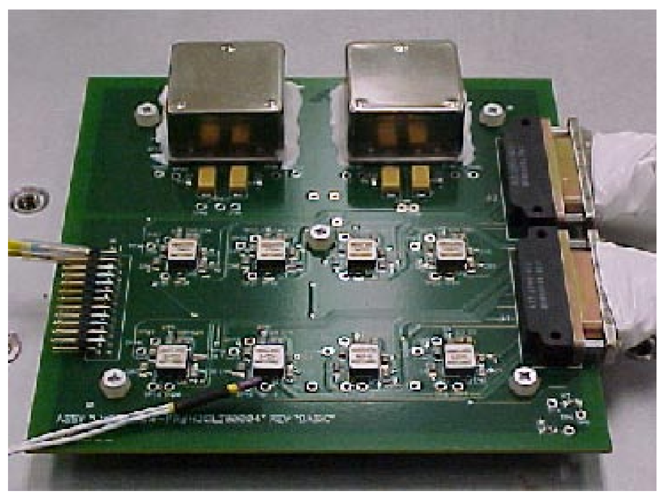
Micro-electro-mechanical systems (MEMS) inertial sensors such as accelerometers and rate gyros have become well-established components in certain terrestrial applications such as the automotive and consumer electronics industries. Design requirements and product specifications, however, are most often aimed at high volume and low cost. In many cases, these requirements run counter to NASA's typical low-volume and high-performance usage profile. Although this discrepancy poses a hurdle in NASA's application of MEMS devices, the potential payoffs are simply too great to ignore. Emerging MEMS technologies offer the possibility for orders of magnitude reductions in size, power consumption, and cost when compared to their macro-scale contemporaries. In many cases, these properties are an enabling technology in a design or an enterprise. In order to apply these characteristics, however, potential users must fully understand the device limitations and integration issues.



High-temperature test personal computer board.

A joint Engineering Directorate and Safety and Mission Assurance Directorate project has tested two widely available commercial single-axis MEMS rate sensors, the Analog Device ADXRS150 and the BAE Systems SiRRS01. These tests have focused in two broad areas: baseline performance testing across relevant environmental parameters and across time, and characterization and prediction of rate sensor reliability via accelerated thermal vacuum testing. To maximize testing efficiency, we manufactured a high-temperature test personal computer board to house eight analog devices and two BAE gyros. This allowed simultaneous multi-sample data collection to provide statistics on the performance and reliability data.

Testing chamber.

Performance testing is done in a thermal rate chamber, and focuses on device sensitivities to temperature and device changes across long durations—six months or more. As mechanical devices, the properties of the gyros can vary greatly with temperature and we have to fully understand and compensate for these variations to optimize performance.

We also need to understand changes in gyro operating characteristics over long periods so we can adjust accordingly a particular application. We designed the current suite of tests to examine gyro parameters such as bias and scale factor over time and temperature.

We achieved accelerated stress testing by operating the gyro in a thermal vacuum chamber at widely varying temperatures. Testing included a ramped swing test during which temperature was oscillated and increased; 24-hour stress tests at 100ºC, 125ºC, and 160ºC; and a 24-test that cycled between –45ºC and 125ºC. We expected these tests to reveal functional and performance failures for the devices and provide a basis for reliability estimates.

We have collected full sets of data ,and analysis is ongoing. Initial results were to be published in fiscal year 2005 for both the performance and the reliability tests. The project is also coordinating with the Engineering Directorate MEMS and Nanotechnology Initiative to use processes and documentation generated as a starting point for MEMS testing standards at Johnson Space Center.