

# TEST CAPABILITIES APPLIED TO SPACE RATE SENSORS FOR TACTICAL AND SPACE INERTIAL REFERENCE NAVIGATION AND SMALL SATELLITE APPLICATIONS

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**Abstract:** Inertial Reference Units (IRUs) are key components for angular rate sensing for guidance, navigation, and control in tactical, space, small satellite (small sat), and cube satellite (cube sat) applications. Test capabilities are described that were selected to demonstrate capability of a three-axis HG4934SRS Space Rate Sensor (SRS). As an example, the HG4934SRS uses tactical and space rated parts with performance that includes a dynamic range of  $\pm 200$  degrees/second, maximum  $3\sigma$  gyro bias (including repeatability, where  $3\sigma$  equals three standard deviations) of  $< 225$  degrees/hour, in-run  $3\sigma$  bias stability (over temperature at  $> 0.75$  °C/minute)  $< 3$  degrees/hour, and  $3\sigma$  scale factor less than 3000 parts per million; with a mass  $< 145$  g, volume  $< 82$  cm<sup>3</sup>,  $< 3$  W nominal power consumption,  $< 5.5$  W peak power consumption,  $5$  V  $\pm 10\%$  power, mission life  $> 6$  years including for Low Earth Orbit (LEO) missions, storage life  $> 10$  years, and an operating temperature range spanning  $-41$  °C to  $+71$  °C. To support expected life estimation, risk assessment, confidence analysis, mission class categorization, development, and qualification for component, module, and system applications, testing that such IRUs must pass are based on available test capabilities. Such test capabilities include environmental, electro-magnetic, and radiation environments testing. Environmental (ENV) testing and test capabilities performed at or by Honeywell in Minneapolis, MN, include vibration, shock, sine vibration, half-sine shock, acoustic, temperature, temperature shock, temperature/altitude, rapid decompression, and temperature/humidity testing, performed, e.g., per MIL-STD-810. Electro-magnetic interference (EMI) testing and test capabilities performed at or by Honeywell in Minneapolis, MN, include conducted susceptibility (CS), conducted emissions (CE), radiated susceptibility (RS), and radiated emissions (RE) testing performed, e.g., per MIL-STD-461. Radiation environments testing and test capabilities include total ionizing dose (TID) and single-event effects (SEE) performed, e.g., per MIL-STD-883, MIL-STD-750, MIL-HDBK-814, ESCC 22900, and

ESCC 25100. Radiation test capabilities, such as for TID and SEE testing, were applied by Honeywell, Clearwater, FL, which features a full suite of in-house radiation test sources, analysis tools, and resources, in coordination with Honeywell, Minneapolis, MN, and other sites. Passing results were obtained for levels of interest, such as for natural radiation (e.g., LEO) with TID  $> 18$  krad(Si) and an SEE MTTF  $> 2,000$  years. Latch-up and functional interrupts are managed via fault detection and correction (FDC) and power management.

**Keywords:** Inertial Reference Unit, IRU, Space Rate Sensor (SRS), Testing, Environmental Testing, Electro-Magnetic Interference, Radiation Hardness, Guidance, Navigation, Control.

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