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DYNAMIC RADIATION TESTING ON COMMERCIAL INTEGRATED MEMS INERTIAL NAVIGATION SYSTEM WITH X-RAYS AND ELECTRONS

Abstract

In this contribution we report advances in radiation testing at the particle accelerator laboratory of ENEA Frascati Research Centre on a commercial 9-axis integrated MEMS inertial measurement unit (IMU) (accelerometer, gyroscope and magnetometer). This commercial component has already been the focus of a previous experimental campaign, reported at IAC 2019, where the device was tested in mechanically static and electronically dynamic conditions for combined total ionizing dose (TID) and Single Event Effects (SEE) with 30 MeV proton beam from the TOP-IMPLART linear accelerator. Commercial off the shelf (COTS) products of the same class of the component under test, not designed for harsh environment, could be used as sensors for attitude determination in University Cubesat missions and tested for radiation resistance with the procedure we are investigating.

The COTS IMU is here tested at the REX (Removable Electron X-rays) facility based on a S-band linear accelerator which can provide electron beams up to 5 MeV and bremsstrahlung X-rays beams via a conversion head with tungsten target. The accelerator operates delivering 3 s long charge pulses at a variable repetition frequency and with a peak current of about 140 mA. For the present work typical

average working current is 8 A at 20 Hz repetition frequency. Sample irradiation is performed in air within a 300 x 400 x 500 mm3 chamber shielded with lead. Dose rates and dose uniformities can be varied (for both X-rays and electron) choosing different geometrical layout inside the irradiation chamber.

The purpose of the experiment is to confirm the TID resistance, already evaluated up to 50 krad(Si) with the TOP-IMPLART proton beam, and further probe the device degradation at higher dose levels by X-rays and electrons irradiation. While X-rays irradiation alone is adequate to investigate TID-only response of the device, electrons in this energy range are also relevant as a radiation source as they are representative of the trapped particles environment that the device could actually be subjected to.

To obtain meaningful data to compare with proton data, the IMU is first irradiated in a fixed position and operation parameters are acquired online with the same procedure and instrumentation of the previous campaign. The outcome of irradiation with the three sources, X-rays, electrons and protons, is discussed, highlighting advantages and disadvantages of the different procedures towards the definition of a simple yet meaningful risk assessment strategy for this kind of devices.

Secondly, the device is irradiated in an improved experimental set-up which allows online acquisition of the accelerometer and gyroscope data in a mechanically dynamic configuration. The IMU board is kept orthogonal to the incident beam and moved along an arc within the 90

This test campaign, through the use of complementary radiation sources (X-rays and low energy electrons vs protons), will allow verification of the cause of degradation on the IMU performance that have already been observed with proton irradiation by separation of cumulative from stochastic effects: noise increase, bias changes (attributed to TID) and zero or end of scale readings, loss of communication (attributed to SEE).