63rd International Astronautical Congress 2012

Paper ID: 14524
student

EARTH OBSERVATION SYMPOSIUM (B1)
Earth Observation Sensors and Technology (3)

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A RADIATION HARDENED DIGITAL FLUXGATE MAGNETOMETER FOR SPACE APPLICATIONS

Abstract

The University of Alberta (UofA), working with experienced Canadian industry, has developed a prototype modern digital, radiation hardened fluxgate magnetometer for space applications. The instrument was developed for the Canadian Space Agency (CSA) "Outer Radiation Belt Injection, Transport, Acceleration and Loss Satellite" (ORBITALS) small satellite mission but is currently being adapted for a range of future Canadian and international science and exploration missions as well as suborbital applications. Magnetic measurements on ORBITALS are technically challenging as the instrument must resolve transient field variations two million times smaller than the background field and track the spinning reference frame of the satellite. These measurements must be made while surviving and operating within the earth's radiation belts.

The core fluxgate design has more than two decades of terrestrial heritage having been previously deployed in the Canadian and US CARISMA/CANOPUS, POLARIS, and EMScope/EarthScope USArray instruments built by Narod Geophysics Ltd. The design was subsequently modified for low-radiation space application in the CSA ePOP payload on the CASSIOPE satellite. To meet the ORBITALS criteria, we redesigned the ePOP instrument replacing analog signal conditioning circuitry with FPGA based digital processing to mitigate radiation and temperature effects. We implemented a novel digital feedback process to improve the measurement bandwidth, reduce complexity and physical size, achieve the mission's resolution requirements, and remove any dependency on radiation sensitive parts. This paper describes instrument improvements, key subsystems, design choices, the resulting performance and the anticipated science implications.

The instrument samples the DC magnetic field at a minimum of 128 samples per second with a resolution of <¡ 20 pT. A fast slewing architecture maintains this resolution over the varying DC field of a highly elliptical orbit. The prototype is designed to be built from minimum 100 krad components, to mitigate deep dielectric charging, survive and recover from single event upsets and is optimized for mass, power and volume efficiency on a small-satellite platform. The result is a modernized, digital fluxgate magnetometer suited for many ground, space and suborbital applications. It is currently being considered as a secondary plasma science instrument on Canada's proposed flagship "Polar Communication and Weather" satellite constellation and for use in the emerging field of space weather forecasting. The first test flight is expected in 2013 as a Canadian instrument contribution to the Norwegian ICI-4 sounding rocket mission.