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Design and Performance of the Compact Five-channel VLF Wave Receiver on the CANVAS CubeSat Mission

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The Climatology of Anthropogenic and Natural VLF wave Activity in Space (CANVAS) CubeSat mission, scheduled to launch in early 2024, will make continuous measurements of VLF wave activity from low-Earth orbit. These measurements aim to provide a global picture of VLF wave injection from the ground, primarily due to lightning and VLF transmitters, into the magnetosphere, covering frequencies from 0.3 to 40 kHz. The mission will quantify the energy injected into the magnetosphere from below; assess the wave-normal angles of injected waves; and quantify the transionospheric absorption of these VLF waves, by utilizing conjunctions with ground-based VLF receivers.

To enable these measurements, a five-channel VLF receiver has been developed to fit within a CubeSat form factor. Three components of the magnetic field are measured using three 9.5 cm-long search coils, mounted on the end of a 1-meter deployable carbon fiber boom. The boom, deployment mechanism, search coils, integrated preamplifier, and holder fit in under 2U volume. Two channels of electric field are measured by four 40 cm deployed rigid antennas, creating two orthogonal dipoles 90 cm in length tip-to-tip. These antennas deploy using a simple hinge mechanism built into the CubeSat top panel, with an integrated preamplifier board. The instrument electronics include analog amplifiers and anti-alias filters, ADC drivers, and ADCs for each channel, which feed a single FPGA for data processing. All electronics fit on two 90×94 mm PCBs, together using only 0.2U volume. Onboard processing in the FPGA reduces the data to 1-second spectra and cross-spectra with 57 log-spaced frequency bins, plus ten bins dedicated to known VLF transmitter frequencies. This processing reduces the data to about 200 MB per day, enabling downlink of continuous data. Both instrument components have been built and tested in their flight-ready configurations, and are undergoing integration into the CANVAS spacecraft. In this talk we present the instrument design and performance, demonstrating the capability of high-quality VLF measurements in a CubeSat form factor.