A Compact 118GHz Radiometer for the Micro-sized Microwave Atmospheric Satellite (MicroMAS)[1]

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A novel compact radiometer observing nine channels near the 118.75GHz oxygen absorption line is introduced. The radiometer is designed as the payload for the Micro-sized Microwave Atmospheric Satellite (MicroMAS). MicroMAS is a dual-spinning 3U CubeSat that aims to address the need for low-cost, mission-flexible, and rapidly deployable spaceborne sensors. The focus of the current MicroMAS mission is to observe convective thunderstorms, tropical cyclones, and hurricanes from a near-equatorial orbit. As a low cost platform, MicroMAS offers the potential to deploy multiple satellites, in a constellation, that can provide near-continuous views of severe weather. The existing architecture of few, high-cost platforms, infrequently view the same earth area which can miss rapid changes in the strength and direction of evolving storms thus degrading forecast accuracy. MicroMAS is a scalable CubeSat-based system that will pave the path towards improved revisit rates over critical earth regions, and achieve state-of-the-art performance relative to current systems with respect to spatial, spectral, and radiometric resolution. The current MicroMAS mission will demonstrate the viability of CubeSats for high-fidelity environmental monitoring and space control that would provide profound advances by reducing costs, by at least an order of magnitude, while increasing robustness to launch and sensor failures. This discourse focuses on the compact radiometer designed for this CubeSat mission. The radiometer is housed in a 1U (10 x 10 x 10 cm) payload section of the 3U (10 x 10 x 30 cm) MicroMAS CubeSat. The payload is scanned about the spacecraft's velocity vector as the spacecraft orbits the earth, creating crosstrack scans across the earth's surface. The first portion of the radiometer comprises a horn-fed reflector antenna, with a full-width at half-maximum (FWHM) beamwidth of 2.4º. Hence, the scanned beam has an approximate footprint diameter of 20Km at nadir incidence from a nominal altitude of 500Km. The antenna system is designed for a minimum 95% beam efficiency. The next stage of the radiometer consists of superheterodyne front-end receiver electronics with single sideband (SSB) operation. The front-end electronics includes an RF preamplifier module, a mixer module, and a local oscillator (LO). The RF preamplifier module contains a low noise RF amplifier and a weakly coupled noise diode for radiometric calibration. The mixer module comprises a HEMT diode mixer and an IF preamplifier MMIC. The LO is obtained using a 30GHz dielectric resonant oscillator (DRO) and a resistive diode tripler to obtain a 90GHz LO frequency. A key technology development in the MicroMAS radiometer system is the ultra-compact intermediate frequency processor (IFP) module for channelization, detection, and analog-to-digital conversion. The antenna system, RF front-end electronics, and backend IF electronics are highly integrated, miniaturized, and optimized for low-power operation. The payload also contains microcontrollers, with one of such being in the payload interface module (PIM), to package and transmit radiometric and housekeeping data to the spacecraft bus. A voltage regulator module (VRM) was also designed for the payload to convert the input bus voltage to the required voltages for the payload electronics. The payload requires 3W (average) of power. The MicroMAS payload flight unit is currently being developed by MIT Lincoln Laboratory, and the spacecraft bus flight unit being developed by the MIT Space Systems Laboratory and the MIT Department of Earth and Planetary Sciences for a 2014 launch to be provided by the NASA CubeSat Launch Initiative program.

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