Tropospheric Water and Cloud ICE (TWICE) Millimeter- and Sub-Millimeter-Wave Radiometer for 6U-Class Satellites: Performance Analysis of Command and Data Handling (C&DH) Subsystem

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The Tropospheric Water and Cloud ICE (TWICE) instrument is a wide-band millimeter- and sub-millimeter wave radiometer measuring at 15 frequencies from 118 GHz to 670 GHz. The TWICE instrument is designed to provide measurements of upper tropospheric water vapor and ice particle size distribution in clouds on a global basis at a variety of local times. TWICE is being developed by a collaboration led by Colorado State University (CSU) in partnership with the Caltech Jet Propulsion Laboratory (JPL) and Northrop Grumman Aerospace Systems. TWICE will use 25-nm InP High Electron Mobility Transistor (HEMT) low-noise amplifier-based (LNA) receiver front-ends to provide low-noise and low-power operation in a small form factor at millimeter- and sub-millimeter-wave frequencies. TWICE radiometers will perform end-to-end calibration once each scan by viewing both cold space (2.7 K) and an ambient calibration target at a known thermodynamic temperature. TWICE is designed for operation in a 6U-Class satellite (6U CubeSat) with dimensions of 34 cm x 20 cm x 10 cm and mass up to 12 kg.

A low power consumption back-end board has been designed to perform analog-to-digital conversion of 16 radiometric signals. An on-board FPGA performs command and data handling (C&DH) functions. These include the radiometric calibration sequence and scanning motor control, as well as analog-to-digital conversion of thermodynamic temperatures in strategic locations on the instrument and the current consumption of critical subsystems. To accommodate the 6U CubeSat form factor, the C&DH subsystem needs to meet specific requirements on mass, volume and power consumption. Furthermore, this subsystem must properly interface with the rest of the system.

To date, prototype versions of the C&DH subsystem have been fabricated and tested, and their performance has been analyzed. Noise analysis of the data acquisition system has been performed in both time and frequency domains. A reliable and robust hybrid power regulation and distribution system has been designed using linear and switching regulation circuits, as appropriate to maximize power efficiency. The power regulation performance has been measured in terms of both load regulation and power efficiency. Finally, the overall C&DH subsystem has been designed, along with interfaces to other subsystems of the TWICE instrument.