Design and Analysis of Command and Data Handling Subsystem for Tropospheric Water and Cloud ICE (TWICE) 6U-Class Satellite Instrument

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The Tropospheric Water and Cloud ICE (TWICE) instrument is under development to provide global observations of upper tropospheric water vapor and ice particle size distribution in clouds at a variety of local times. TWICE is a wide-band millimeter- and sub-millimeter wave radiometer measuring at 15 frequencies from 118 GHz to 670 GHz. The TWICE instrument is being developed by a collaboration led by Colorado State University (CSU) in partnership with the NASA/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) millimeter- and sub-millimeter-wave receiver front-ends to provide low-noise and low-power operation in a small form factor. TWICE radiometers will perform end-to-end calibration once each scan by viewing both cold space (2.7 K) reflector and an ambient calibration target at a precisely 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 power-efficient, low-noise command and data handling (C&DH) subsystem has been designed to perform the acquisition of the 16 analog radiometer outputs and provide the required power supplies for the other subsystems of the TWICE radiometer instrument. An on-board FPGA provides command and control of other instrument subsystems, performs synchronous data acquisition and manages interfaces of the other TWICE subsystems. The C&DH subsystem is designed to fit within key size, weight and power (SWaP) requirements imposed by the 6U-Class satellite form factor.

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 in both time and frequency domains has been performed to show that requirements are met. A reliable and robust power regulation and distribution system has been implemented in a hybrid fashion. This means that both linear and switching regulation circuits are utilized as appropriate to maximize power efficiency and provide supply voltages with low noise. Measurements of power regulation performance have been performed to characterize both load regulation and power efficiency. Heavy-ion radiation testing has been performed for critical commercial-of-the-shelf (COTS) electronic parts. The integration of the prototype C&DH subsystem with the prototype 670-GHz receiver is in progress. The final development of the C&DH subsystem will be based on results of functionality and environmental tests of the prototype subsystem.