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

Mehmet Ogut*(1), Xavier Bosch-Lluis(1), Steven C. Reising(1), Yuriy V. Goncharenko(1), Pekka Kangaslahti(2), Erich Schlecht(2), Richard Cofield(2), Nacer Chahat(2), Sharmila Padmanabhan(2), Jonathan Jiang(2), Shannon T. Brown(2), William R. Deal(3), Alex Zamora(3), Kevin Leong(3), Sean Shih(3) and Gerry Mei(3)
(1) Microwave Systems Laboratory, Colorado State University, Fort Collins, CO 80523 USA
(2) Jet Propulsion Laboratory, NASA/California Institute of Technology, Pasadena, CA 91109 USA
(3) Northrop Grumman Corporation, Redondo Beach, CA 90278 USA

1. Extended Abstract

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 observations of upper tropospheric water vapor and ice particle size distribution in clouds on a global basis at a variety of local times. TWICE is under development 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-noise, power-efficient command and data handling (C&DH) subsystem has been designed to control TWICE data acquisition and perform analog-to-digital conversion of 16 radiometric signals. An on-board FPGA performs 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. The C&DH prototype board meets the size, weight and power (SWaP) requirements for deployment in a 6U-class satellite.

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 the time and frequency domains. Considering the limited power resources available on such platforms, a highly-efficient power regulation and distribution subsystem has been designed using linear and switching regulation circuits, as appropriate to maximize power efficiency and reduce system noise. The power regulation performance has been measured in terms of both load regulation and power efficiency. Finally, the C&DH subsystem has the capability to interface properly with other subsystems of the TWICE instrument.