Tropospheric Water and Cloud ICE (TWICE) Instrument Development for 6U CubeSat Deployment: Back-End Electronic Design and Testing

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Starting with the first CubeSat specifications initiated by Cal Poly and Stanford in 1999, CubeSats have primarily been a very low-cost way to provide small experiments built by universities with access to space as secondary cargo on launches of opportunity. Starting in 2010, NASA's CubeSat Launch Initiative (CSLI) provides launch opportunities for educational institutions and non-profit organizations as auxiliary payloads on previously planned missions. However, the maturation of CubeSat technology and associated industrial spacecraft providers provides the potential to accomplish future Earth science measurements that are either prohibitively expensive or impractical to be accomplished on larger missions, such as NASA's Soil Moisture Active Passive (SMAP). In addition, the short development cycles of CubeSats allow the rapid infusion of new technology for Earth science measurements as well as graduate student participation from concept to operations within the typical time span of a Ph.D.

This new landscape has led to development of innovative Earth science instruments for CubeSats, including Tropospheric Water and Cloud ICE (TWICE), under collaborative development by Colorado State University (CSU), the Caltech Jet Propulsion Laboratory (JPL) and Northrop Grumman Aerospace Systems. TWICE is a wide-band millimeter and sub-millimeter wave radiometer with both window and sounding channels ranging from 118 GHz to 670 GHz. TWICE will use InP High Electron Mobility Transistor (HEMT) technology in low-noise amplifier-based (LNA) front-ends at millimeter and sub-millimeter wavelengths to provide fine radiometric resolution at these frequencies. In addition, TWICE is designed for operation in a 6U CubeSat with dimensions of 10 cm x 20 cm x 30 cm and a mass of up to 12 kg. The main scientific goal of TWICE is to provide global measurements of upper tropospheric water vapor as well as size of ice particles and total ice content in clouds at a variety of local times.

A low power consumption back-end board has been designed to sample the 16 analog radiometric signals as well as provide control and data handling, including the calibration sequence, scanning motor and housekeeping information such as thermal status and current consumption. To fit into a 6U CubeSat, the back-end board needs to meet stringent limitations on mass, volume and power consumption. Moreover, a challenging part of the design is for highly reliable operation in the space radiation environment and thermal gradients in non-sun synchronous Low Earth Orbit (LEO). To mitigate these effects, ADCs with both Sigma-Delta and Successive Approximation Register (SAR) architectures will be tested under thermal cycling at CSU and Single-Event Upset (SEU) LEO-like conditions at Texas A&M Cyclotron Laboratory.