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ULTRA-HIGH THROUGHPUT E/W-BAND DOWNLINK CUBESAT MISSION

Abstract

The demand for high data rate communication is driving the use of higher frequencies of the microwave spectrum. It has been demonstrated that transmission links using the waveguide E-band (IEEE V/W-band) are feasible for terrestrial and aviation links, but such radio equipment for space applications is still novel. Thus, the objective of the Exploratory In-orbit Verification of an E-band link (EIVE) project is to investigate the capabilities of an experimental transmitter operating at 71-76 GHz. The E-band transmitter, developed by the Institute of Robust Power Semiconductor Systems, Fraunhofer IAF and Radiometer Physics GmbH, is selected as the primary payload for a 6U CubeSat.

An alternative to laser communication terminals, prone to signal drop-out in case of adverse atmospheric conditions, is presented by high frequency radio communication systems. The EIVE project proposes a data downlink in the 71-76 GHz frequency band from a 6U CubeSat flying in LEO to a base station in Stuttgart. The data downlink from a CubeSat platform will firstly demonstrate the feasibility of broadband radio links in a frequency range new to satellite communications in an in-orbit verification. Secondly, it addresses Earth observation applications and ultra-high throughput services with the planned payload, and finally evaluates the atmospheric effects on modulated data in this frequency range. A computationally powerful miniaturized digital processing unit, multiMIND, in combination with a 12 GSps D/A extension board is used to feed the high-speed analog link. A novel compact base-station with integrated high-speed digital processing, storage unit and satellite tracking will meet the high data throughput and low-noise receiver requirements of the base station in an urban area close to sea-level. The EIVE satellite is currently in test phase, and it is scheduled to fly in 2022.

This paper describes the CubeSat mission along with the scientific payload design and qualification tests. Detailed dynamic link budget calculations show the feasibility of a transmission in a polar low-earth orbit with a very large bandwidth of 5 GHz while using realistic compact antenna dimensions. Data rates over 15 Gbps in complex modulation formats are expected to be demonstrated in-orbit under ideal weather conditions, while data rates over 6 Gbps are still expected under adverse atmospheric and weather conditions. Successful TRL4 laboratory experiments based on the actual satellite payload have been conducted, and TRL6 terrestrial and aeronautic E-band links employing a similar transceiver technology based on a GaN SSPA transmitter and InGaAs low-noise receiver were conducted.