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ON-ORBIT RESULT OF ONBOARD PROCESSING OF UHF RANGING SIGNAL FROM THE GROUND FOR TOTAL ELECTRON CONTENT MEASUREMENT OF SPATIUM PROJECT

Abstract

In order to understand the dynamics of ionosphere, global 3D ionospheric map that can capture the time fluctuation of the ionosphere is needed. SPATIUM (Space Precision Atomic-clock TIming Utility Mission) project aims at 3D mapping of the ionosphere using a CubeSat constellation. This project was developed collaboratively at Kyushu Institute of Technology and Nanyang Technological University. The objective is to elucidate the dynamic interaction of the atmosphere, ionosphere, and magnetosphere. SPATIUM-II is the second generation of the SPATIUM project. SPATIUM-II occupies 1U (10cm x 10cm x 10cm) volume of KITSUNE 6U single CubeSat which was released from the International Space Station on March 24, 2022. The electrons of the ionosphere result in radio wave propagation time delay. The propagation time delay of ranging signal is proportional to an ionospheric total electron content (TEC). SPATIUM-II aims to process ranging signal, 450MHz, and derive propagation time delay for estimating

the TEC. This paper describes the on-orbit result and analysis of SPATIUM-II's TEC measurement mission and the lessons learned for next generation. It was challenging to measure the propagation time delay of ranging signal onboard which was transmitted from the ground. SPATIUM-II performed onboard processing using software defined radio, Raspberry Pi, Chip-Scale Atomic Clock (CSAC) and GNSS receiver. To derive propagation time delay, SPATIUM-II had two ranging signal receiver modules at the ground station and at the CubeSat. These two modules were synchronized by inserting one pulse per second (1-PPS) of GNSS receiver into the received analog ranging signal. The ranging signal of Spread Spectrum (SS) was despreaded, and the time difference between the rise time of 1-PPS and the time of the header of SS chip pattern was derived at each module of the ground station and the CubeSat. The difference between these each time differences is the measured propagation time. The propagation time delay is calculated by subtracting the propagation time using the speed of light from the measured propagation time.