Design, implementation, and tests of the architecture of the radiocommunication system of the OUFTI-1 CubeSat

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OUFTI-1 is a nanosatellite of type CubeSat under development at the University of LiŔge, in collaboration with several partners. Its telecommunication system consists of three parts working on the amateur-radio ('ham") UHF (uplink) and VHF (downlink) bands. One is a repeater implementing the ham D-STAR protocol, which is capable of simultaneous transmission of digital voice and data and of roaming via the internet ; this is the main payload of the satellite. The others are a telecommand/telemetry (TC/TM) channel using the ham AX.25 (digital) protocol, and an emergency Morse-code beacon. The heart of each of these systems are MSP430 microcontrollers for, among others, encoding or decoding the digital data, ADF7021 transceivers that convert the digital data to the appropriate radiofrequency (RF) signal and vice-versa, and RF parts at the receive (Rx) and transmit (Tx) ends. We now describe the communication (COM) architecture of the satellite.

Distinct UHF frequencies are used on uplink for D-STAR and AX.25. At any time, the incoming signal can consists of a D-STAR signal, or an AX.25 signal, or both. This signal is passed through a low-noise amplifier (LNA), split, and simultaneously processed by two ADF(7021)s set in Rx mode, one dedicated to D-STAR and the other to AX.25. TCs (arriving via AX.25) always have priority. Due to the constraint of current, conventional D-STAR equipment on the ground, we were led to provide Doppler corrections (because of the 8 km/s orbital speed) on-board. The strategy is to listen to two separate zones in the antenna footprint of the satellite, thus with distinct Doppler shifts. The pair of shifts is updated by TC from the ground. The D-STAR ADF alternately scans these two frequencies for incoming signals.

The AX.25 frames and the D-STAR frames are respectively (de)coded by the on-board computer (OBC)'s MSP(430)s and by a COM-dedicated MSP. A dedicated serial line is used for communication between these MSPs, e.g. to send the Doppler corrections from the OBC (which handles AX.25) to the COM-dedicated MSP (which handles D-STAR). A single ADF set in Tx mode is used by D-STAR and AX.25. The appropriate data is sent to it via a multiplexer. Similarly to Rx, AX.25 TM always has priority. For reliability reason, the beacon has its own pair of MSPs and its own ADF. The outputs of the D-STAR/AX.25 ADF and of the beacon ADF are brought together and sent to the Tx power

amplifier. The D-STAR and AX.25 protocol have been implemented and successfully tested in earlier version of the hardware architecture. Successful D-STAR transmission tests were performed by (1) transmitting via an ICOM IC-E2820, (2) receiving, decoding, reencoding, and retransmitting by our own electronic boards, and (3) receiving via another IC-E2820. Successful tests were also performed for AX.25. The beacon is operational. A new COM engineering-model PC board implementing the new architecture above is under development.