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TESTING AND IMPLEMENTATION OF COMMUNICATION SUBSYSTEM OF A 3U CUBESAT USING SOFTWARE-DEFINED RADIO

Abstract

This paper presents the Communication Subsystem's testing and implementation by students of Team Anant, BITS Pilani, for their 3-U multispectral imaging CubeSat. Multispectral images are large and sensitive; hence a reliable system must be built for high-speed communication. S-band is thus chosen as the primary downlink system along with a provision of downlinking in UHF as per the power budget, while uplink will take place in UHF. The paper begins with discussions on objectives and requirements from the Software-Defined Ground Station, which is versatile, cost-cutting, and gives space for improvement in contrast to the traditional hardware-defined ground stations. Based on this, the ground station architecture, consisting of rotors, filters, amplifiers, Software-Defined Radio (SDR), and a control computer, has been designed. GNU Radio, an open-source software, which allows for an extremely flexible and customizable system is chosen for signal processing at the ground station. The GNU Radio flowgraphs for modulation/demodulation, packet framing/de-framing, and error correction will be discussed for the uplink/downlink and backup downlink system. This paper also presents testing using channel emulators, which helps closely replicate the realistic channel impairments such as Doppler shift, path loss, and propagation delay. C codes used for onboard packet framing and error-coding are tested using UDP ports where the framed packets are sent to GNU Radio for decoding and further interpretation. Doppler correction is done using gpredict. Lastly, for testing the complete framework, an Arduino UNO Development board is interfaced with Texas Instruments CC1101 and Texas Instruments CC2500 transceivers for UHF and S-band respectively on the onboard side, while the base-station side signal processing is performed on GNU Radio using a HackRf-SDR. This aids in settling on parameters such as frequency offset, sampling rate, filters required, decimation which is required as input by various blocks in the GNU Radio software and furthermore gives an insight on the BER(Bit Error Rate) and threshold of various losses that the system can withstand for a given Signal-to-Noise Ratio. The paper concludes by discussing the limitations faced and further improvements that can be made in the current system.