IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advances in Space-based Communication Systems and Services, Part 2 (2)

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THE IMPLEMENTATION OF A SOFTWARE-DEFINED BASEBAND SYSTEM FOR SATELLITE TELEMETRY AND TELECOMMAND

Abstract

Software Based Radio (SDR) is becoming an interesting technology for satellite ground station networks, in order to improve flexibility, reliability and an increased level of integration. This is in particular for the relatively low bitrate TTC communications where the computational power can be managed with standard IT hardware and software. This paper presents the development and experience gained in an industry-university collaboration for the development of a prototype for an CCSDS compatible SDR baseband system. The system is aimed for TTC services and based on commercial-off-the-shelf (CoTS) RF frontends and the open source GNU Radio platform. The design process is demonstrated by the use functional flow block diagrams (FFBD) for all functionality for the telemetry receiver and telecommand transmitter. The functions involved in the telemetry receiver are bit synchronization and forward error correction (FEC) decoding. The FECs codes in question are the standard Consultative Committee for Space Data Systems (CCSDS) FECs codes namely convolutional, Reed-Solomon and concatenated Reed-Solomon and convolutional codes. The functions involved in the telecommand transmitter are bit modulation, channel link transfer unit (CLTU) generation and modulation. The physical layer operations procedures (PLOPs) are also part of the telemetry transmitter. After the design process, the paper presents the verification process, which is simulated in the software environment for various modulation schemes and FEC codes under realistic satellite channel model. The channel model includes satellite transponder impairments, Doppler shift and rate, ground station impairments as well as RF frontend imperfections. The verification process evaluates the performance of the baseband system by comparing against nominal performance according to CCSDS. Following verification is validation, which involves the evaluation of system performance with realistic satellite signals. The validation process is first conducted in laboratory environment where emulated satellite signals generated by a commercial baseband systems are received by the developed baseband system and henceforth evaluates the performance for the telemetry receiver. Tests for the telecommand transmitter was performed to commercial baseband as well as further validated by sending telecommands to a satellite emulator. Following this, relevant signals of orbiting satellites using CCSDS has been recorded and used in a successful validation campaign.