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CHARACTERIZATION OF A CCSDS-COMPLIANT SOFTWARE DEFINED RADIO ARCHITECTURE FOR DEEP-SPACE MICRO SATELLITES

Abstract

One of the essential functions of any spacecraft is the ability to establish a connection with ground stations or with other spacecrafts to exchange information, commands, control data, etc. For this purpose, spacecrafts use a transceiver to process uplink/downlink signals in terms of filtering, modulation, up/down conversion, demodulation and decoding. One of today's trends is to progressively move all these functionalities to the digital domain using hardware logic and the so-called Software-Defined Radios (SDR). Usually, SDR-based transceiver results in a compact, low power and flexible communication system, with the drawback of requiring expensive, high-performance components. In a typical space application, the basic data flows require a considerably stable communication link to control and command the satellite and to deliver data toward the Earth or other spacecraft. They are often referred to as Telecommand (TC) and Telemetry (TM) services. This paper introduces a receiver design for a TC system having the full compatibility with Consultative Committee for Space Data Systems (CCSDS) Standard as a design driver. The digital signal processing architecture of the system has been studied, developed and software simulated prior the migration on a selected target hardware architecture, in this case a development board equipped with a Xilinx Zynq-7000. Particular focus has been given to an experimental coding scheme: Low-Density Parity-Check (LDPC) codes. LDPC codes are a new class of codes which are growing in popularity. LDPC codes are able to provide significant coding gain by exploiting a soft-decoding technique applied to 'soft symbols' while decoding a Codeword. Soft decision decoding is a class of algorithms that takes a stream of bits, or a block of bits, and decodes them by considering a range of possible valid values. It considers the reliability of each received pulse to build better estimates of input data. The standard suggests the use of LDPC(128,64) or LDPC(512,256) codes. The study presented in this paper aims at verifying an efficient implementation for an SDR receiver investigating the complexity and bit error rate/codeword error rate performances for different iterative and non-iterative decoding. The presented results give a hint for a future feasibility analysis in using hybrid decoding technique to improve the performance of a LDPC decoder. The implementation of the LDPC decoding in a small satellite receiver allows to communicate to the satellite with lower SNRs, thus enabling communication with small satellites at higher distances from Earth.