SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Near-Earth and Interplanetary Communications (6)

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A COMBINED RF/OPTICAL TRANSMISSION SCHEME FOR DEEP SPACE COMMUNICATIONS

Abstract

The CCSDS has generated a white book which is based on the serial-concatenated pulse position modulation. This scheme achieves very good performances in the optical domain, however, it is not applicable in the RF domain at all. Therefore we follow another route, by basing the forward error correction (FEC) scheme on another, very well established standard, the DVB-S2. This standard, widely used in satellite communications achieves a communications performance only 0.7 to 1.2 dB away from the Shannon limit for the Gaussian channel. The DVB-S2 FEC scheme is based on an inner LDPC-code, an interleaver and an outer BCH-code. The RF-modulation scheme can be BPSK, QPSK, 8-PSK, 16-APSK and 32-APSK.

For the RF-link, a commercial available DVB-S2 modulator and demodulator is considered as baseline. However, for the optical link this papers covers the adaptation of the DVB-S2 modulator/demodulator for the optical link. The DVB-S2 encoder, which is part of the RF-modulator, provides the FEC for the optical link as well. The In-Phase-and Quadrature-Phase signals feeding the modulator are also used to drive the optical link the 16-PPM mapper. The DVB-S2 demodulator will be fed with signals from the 16-PPM de-mapper, which receives the optical signal by a cryogenically cooled nano-wire photodetector and a 16-PPM correlator. The existing demodulator and decoder circuit recovers the bit-clock and finally provides the decoded data stream to the data output interface.

The switch-over between RF-link and optical link is made upon a special command delivered to both DVB-S2 modulator and DVB-S2 demodulator. This switch-over command is derived from the signal reception of a laser beacon from the Earth Optical Ground Station (OGS). If this signal is received by the deep-space probe RF/Optical terminal, the optical link, with its higher data rate capability, is switched on. If the OGS beacon laser signal is not detected, the RF-link is to be evoked. Since the signal travel time is in the order of half an hour, a sufficiently large buffer memory needs to on-board to allow the repetition of the data bits, which are travelling between the deep-space probe and the OGS (about 2 GByte for a 10 Mbit/s data rate). As will be described in more detail, as beacon laser we propose to make use of commercially available satellite laser ranging station (SLR) laser operating in the 532 nm wavelength. The expected performances in terms of bit per photon will be described in the paper as well.