Swiss Space Center
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Bachelor-Diplomarbeit Elektrotechnik

CubETH TMTC Modem — ECSS/CCSDS inspired Space Link

Space Engineering Standards:

ECSS (part of ESA)
European
Cooperation for
Space
Standardization
(based on CCSDS)

CCSDS
Consulative
Committee for
Space
Data
Systems

Did you know?
CubETH will use a coding system similar to that of Voyager 1 and 2, which are earth's farhtest spacecrafts made by mankind.

Uplink (1.2 kbps)
Asynchronous transfer of variable-sized Communications Link Transmission Units (CLTU) with one Telecommand (TC) packet inside.
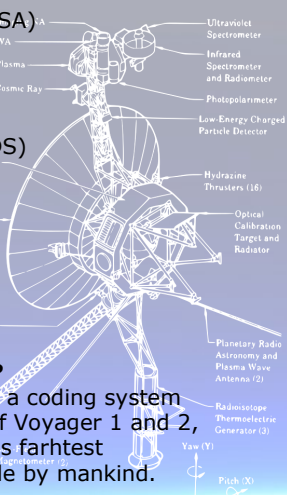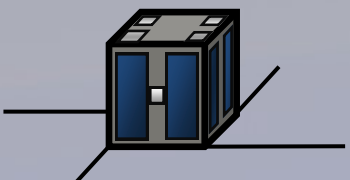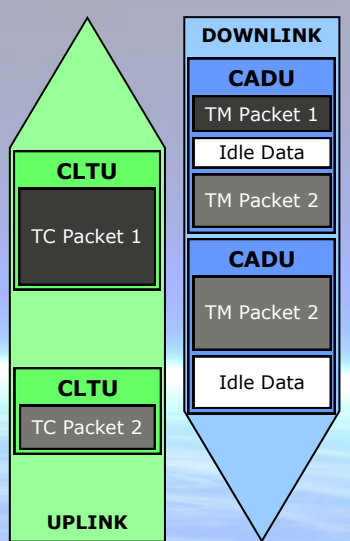
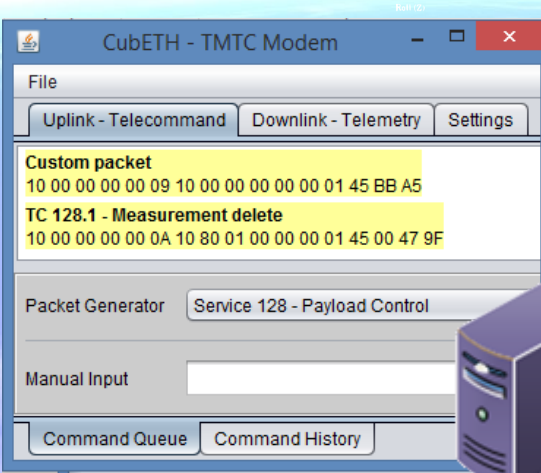Forward error correction:
- Binary BCH Blockcode

Downlink (9.6 kbps)
Synchronous transfer of fixed-sized Channel Access Data Units (CADU), containing Telemetry (TM) packets and/or Idle Data.
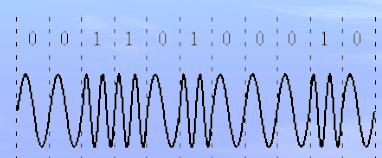
Forward error correction:
- Reed-Solomon Blockcode
  (QR-Codes use this coder, too.)
- Convolutional Code

Channel Coding (Forward Error Correction)
Additional check bits allow correction of errors. Errors occur due to signal interferences.

Modem-to-Radio Interface
Audio Frequency Shift Keying (AFSK)

Computer Soundcard
<- Audio-In: Downlink
-> Audio-Out: Uplink

Problem

The CubETH is a pico-satellite of the size of 10 to 10 to 10 centimeters. Such CubSats can be carried as secondary load of rockets to the low earth orbit. CubETH's main mission goal is to measure its position in space with one meter accuracy and its exact attitude, too. Therefore, GNSS receivers are placed on the payload board of the satellite.

A well performing space link is mission critical, since scientific data has to be downlinked for analysis. On the other hand, measurement commandos and software updates have to be uplinked.

The SwissCube currently in space uses a radio amateur protocol, which performes not very reliable. This time, the communication system should not be the bottle neck anymore.

Solution

A professional space link conform to ECSS/CCSDS standards brings some obvious advantages. The main one is the forward error correction feature, which is essential for a good performing space link. Especially at the downlink, where the sent signals face the earth, there are many possible sources of signal interferences.

They can result in single or burst errors during the transmission.

Only one bit error makes a complete packet unusable. Forward error correction is capable of not only detecting such errors, but also correcting them. The Bit Error Rate (BER) in dependency of the Signal-to-Noise Ratio (SNR) can be lowered.

The end product of this work is the CubETH TMTC modem, which implements the by the standards recommended coding layer. The transfer layer is not completely standard conform, some features have

been omitted, in order to reduce data overhead.

The modem uses the soundcard to interface the transceiver. Therefore, FSK modulation, demodulation and bit synchronization have been topics of this work, too.

Müller Reto

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