A High-Performance GPS Radio Occultation Instrument

Magnus Bonnedal
Jacob Christensen
Saab Ericsson Space, Goteborg Sweden

A high performance radio occultation receiver, GRAS, is being developed at Saab Ericsson Space for the ESA Metop satellites for Eumetsat. In a parallel programme, an instrument, GPSOS, is developed for the NPOESS satellites with IPO (NOAA, NASA & DOD) as customer. The purpose of the instruments is to measure temperature and pressure profiles of the atmosphere and the electron content of the ionosphere.

The basic function of the GRAS instrument is to receive RF signals emitted by GPS satellites as these signals pass through the atmosphere at varying altitudes. The signals are acquired, tracked, and demodulated – the results are then reported to the ground segment in real time, via the payload module down-link system. The signals of the occulting satellites are received through two antennas, one dedicated to the rising occultations and one to the setting occultations. Shaped antenna patterns and dedicated RF front ends ensure a high sensitivity and the capability to measure at low altitudes in the atmosphere, a few kilometres, where the attenuation is high. The measurement at low signal levels is accomplished with a tracking receiver supported by linear parameter estimation techniques.

An extremely high phase measurement accuracy is needed. This requires simultaneous measurements at L1 and L2 to isolate the ionosphere effects, and track the LEO satellite position to an precision of a fraction of an inch, enabling extraction of the atmosphere/ionosphere refraction.

To track the position, the instrument also operates as a navigation receiver. In this context, it receives GPS signals via a third antenna with a hemispherical coverage. It acquires and tracks a set of GPS signals and use limited precision navigation solution to support the autonomous instrument operation. It also provides the position data as part of its measurement data to the payload module to be transmitted to the ground segment. In the ground segment, the data are then used to compute the precise orbit of the spacecraft.

After a single stage down conversion in the RF front the signals are sampled at a high sampling rate and digitally down converted in a DISC ASIC , filtered and delivered to the channel processor. The core of the processor is the AGGA, a dedicated GPS/-GLONASS ASIC, which performs the final down conversion and despreading of the GNSS signals. It is being developed under ESA contract, and contains functionality for tracking the phase and frequency of code and carrier. A number of observables are output to the DSP, which uses them to close the tracking loops and to produce the actual measurement data.

In summary this constitutes a highly embedded system consisting of three independent but well synchronised GPS receiver functions, exercising signal processing and navigation algorithms, providing some 500 high precision occultation measurements per 24 hours.