GSOC'S SCATTEROMETRY GNSS RECEIVER FOR OCEAN REMOTE SENSING: DESIGN AND INITIAL RESULTS

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The department of Space Flight Technology at the DLRs German Space Operations Center (GSOC) is currently developing a new Reflectometry/Scatterometry GNSS receiver for ocean remote sensing. This new GNSS-R instrument is being designed to be used in several conditions ranging from terrestrial applications to spaceborne GNSS Reflectometry/Scatterometry experiments. It computes a Delay-Doppler map (through time multiplexing the Doppler space) on one reflection event at a time using a 3x3 fully digitally steerable antenna array. The specular reflection points (SRP) are dynamically computed for all available GNSS satellites based on the current host vehicle position and a suitable satellite is allocated to the Delay-Doppler processing chain based on certain configurable criteria. The available Delay-Doppler IQ output matrix could be either made available to an external user for later post-processing or it could be digitally processed in the receiver itself to extract the parameters of the signal reflection models. All this is done in real time by the receiver.

A prototype version of this Scatterometry GNSS receiver is being developed as a proof of concept, using the Namuru II board as development platform. Other than traditional GNSS receivers, the Namuru board does not employ a hardware correlator but implements the GPS baseband processing in an FPGA. This allows the hardware processing to be completely customized to different conditions and applications. The basic Namuru II design implements a 12 channel L1 C/A code correlator that closely matches the Zarlink GP2021 correlator. The same correlator forms the basis of DLRs spaceborne Phoenix GPS receiver. This close communality has allowed a direct port of the Phoenix receiver software to the Namuru board and now enables use of the Namuru receiver in high dynamics, spaceborne applications [1].

The current Namuru II hardware offers a dual L1 frontend and can thus concurrently operate a zenith pointing navigation antenna as well as a (left-hand circular polarized) nadir pointing antenna. For beam forming, the latter string will be replaced by a 3x3 antenna with associated frontends.

The digitized IF signal from every antenna in the antenna array is feed to the reflectometry chains for parallel processing. To compute a Reflectometry Delay-Doppler map, the signal from the local digital carrier NCO is used to generate the Doppler space through several evenly spaced Doppler-bins. Similarly the Code-delay space is generated with the digital C/A NCO operating at higher frequency than the L1 C/A chip rate. Both, the Doppler and the Code-delay space size are set dynamically by the receiver depending on the geometry of the signal reflection and eventually on the characteristics and state of the reflecting surface. This is done so to be able to extract as much information as possible from the reflected GNSS signal. The output of every Reflectometry chain is a Delay-Doppler IQ matrix that is updated every 1 ms. To synthesize the antenna array beam, digital beamforming (DBF) is preferred instead of analog beamforming and it is done at the digital-back end of the GNSS Reflectometry/Scatterometry receiver. We implement the digital beamforming after IF carrier and C/A code demodulation. This reduces significantly the technical requirements and cost of the analog RF front-end chain and the computation bandwidth at the FPGA respectively. In this algorithm each element of the Delay-Doppler IQ matrix is rotated and multiplied by a factor before being mixed with the Delay-Doppler IQ matrix of the corresponding reflectometry chain of every other antenna. This then produces the result of one antenna array beam steered to the desired SRP. This Delay-Doppler IQ matrix is then incoherently accumulated over a period ranging from 1 ms to several seconds. This period of accumulation is also set dynamically by the receiver. The output of this accumulation process is then either made available to the input of the digital signal processing HDL modules in charge of the model parameter extraction or is downloaded to an external device for post-processing.

This work has three parts. In the first one, the design of GSOC's Scatterometry GNSS receiver is presented plus a discussion of its major building blocks. The second part presents an analysis of the several hardware modules implemented to generate the Delay-Doppler map with digital beamforming at the FPGA digital back-end of the receiver. Finally, the initial results of ground based campains are presented and analyzed.

References:

[1] A. Grillenberger, R. Rivas, M. Markgraf, P. Mumford, K. Parkinson, and Ch. Rizos, "The Namuru Receiver as Development Platform for Spaceborne GNSS Applications," *4th ESA Workshop on Satellite Navigation User Equipment Technologies*, NAVITEC'2008, 10-12 December 2008, Noordwijk.