IGARSS 2009

Abstract Title

TOGA - a GNSS Reflections Instrument for Remote Sensing Using a Digital Phased Array

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Abstract Body

Remotely sensing the Earth's surface using GNSS signals as bi-static radar sources is one of the most challenging applications for radiometric instrument design. These GNSS signals are on average very weak and in order to ensure high quality observations, a single element low gain antenna might not suffice. This problem can be mitigated by using a high-gain antenna, but with the decreased field of view one can not observe multiple simultaneous reflections as with a lower gain antenna. The solution is to build up an antenna array with multiple lower-gain antennas, but to phase this array such that multiple simultaneous high-gain beams can be formed

As part of NASA's Instrument Incubator Program, our group at JPL has built a prototype instrument, TOGA (Time-shifted, Orthometric, GNSS Array), to address a variety of GNSS science needs. Observing GNSS reflections is major focus of the design and development effort. The TOGA design features a steerable beam antenna array which can form a high-gain antenna pattern in multiple directions simultaneously. Multiple FPGAs provide flexible digital signal processing logic to process both GPS and Galileo reflections. A Linux OS based science processor serves as experiment scheduler and data post-processor.

This paper outlines the TOGA design approach as it applies specifically to observing science quality GNSS-R signals from low Earth orbit. Correct operation of the instrument was verified in various ways, the paper describes both in-lab tests (where phasing is demonstrated using pure tones) and flight tests on a Cessna aircraft where reflected signals were detected off the ocean surface. The instrument can digitally phase up to 16 antennas at three frequencies with 8 independent simultaneous beams. Phased array gain of up to 20dB has been demonstrated using 16 antenna elements.