Real-Time Adaptive Cancellation of GLONASS Interference in OH Signal observations at the Green Bank Telescope

Andrew Poulsen[1]*, Brian D. Jeffs**[1]*, Chad Hansen*[1]*, Karl Warnick*[1]*, and Rick Fisher*[2]
Brigham Young University[1], bjeffs@ee.byu.edu, and
National Radio Astronomy Observatory[2], rfisher@nrao.edu

This paper reports on development and experimental evaluation of a real-time DSP-based adaptive canceller used to remove orbital satellite RFI from radio telescope observations. Effective operation in driving GLONASS interference well below the integrated noise floor has been demonstrated at both the Green Bank Telescope (GBT), and at the Very Small Array (VSA) of four 3 meter dishes located at Brigham Young University. The system is implemented as an LMS adaptive canceller filter with complex coefficients and a programmable delay line for bulk phase shift correction. The canceller's primary channel input is the corrupted telescope signal, and the high interference to signal ratio (ISR) reference source is obtained from a low-cost dish steered to track the offending satellite. At the GBT, this reference antenna is a 3.7 m dish on a AZ-EL mount driven by commercial satellite tracking software. This antenna is located more than a kilometer from the GBT primary. Since the interfering signal is strong at the reference, we were able to use off-the-shelf commercial low noise amplifiers and a simple receiver design.

The programmable DSP platform uses four 200 MHz, high-end Texas Instruments floating point processors and custom digital receiver front-ends. This system performs the following real-time functions: sampling up to four signal channels at 65 MS/s, complex basebanding, band selection, decimation, bandpass filtering, two channel 1024 point power spectrum estimate and accumulation, and 20 complex tap FIR LMS adaptive filter. As compared to a post processing approach to cancellation, the real-time DSP system has several advantages. It can easily be inserted as a transparent front-end process in an existing telescope system, as we have demonstrated at the GBT. No long-duration, high data rate recording is needed, which is particularly useful if the desired output is just the result of a long integration. Post processing adaptive filtering requires huge data storage. DSP hardware (programmable and FPGA based) are now fast enough to support most desired bandwidths (we have demonstrated 1 to 4 MHz BW operation with our system).

The figures below illustrate real-time cancellation performance with a 12 tap FIR. Processing bandwidth is 1 MHz, with 1 kHz bin width for the 1024 point power spectral estimates, which are also computed in real time over 27 seconds of integration. In the left figure, the GBT signal is corrupted by a sidelobe of the GLONASS transmission band. The adaptive filter removes this interference and corrects the noise floor. No OH signal was present. The right figure shows GLONASS cancellation at the VSA. A simulated OH source (FM sweep) obscured in the primary, is clearly visible between 1608.7 and 1608.9 MHz after filtering.