Digital Back-End for the New Ultra-Wideband Feed and Receiver for the Parkes Radio Telescope

Paul Roberts[(1)], Daniel George[(1)], John Tuthill[(1)], Mark Leach[(1)], Ron Beresford[(1)], Michael Brothers[(1)] and Tasso Tzioumis[(1)]
(1) CSIRO Astronomy and Space Science, Marsfield, Australia, 2122
https://www.csiro.au/en/Research/Astronomy

We present an overview of the digital back-end for the new ultra-wideband receiver that was commissioned on the 64m radio telescope antenna at Parkes in New South Wales, Australia in May 2018.

The new Ultra-Wide-Band (UWB) receiver system at Parkes processes an instantaneous bandwidth from 700 MHz to 4 GHz in two polarizations. The total bandwidth is divided into three sub-octave bands "low", "mid" and "high" which are coherently sampled and processed. The frequency edges of the three bands along with their corresponding sample rate are provided in Table 1.

Table 1. UWB processing frequency bands and sample rates.

Band	Frequency range	Sample rate
Low	704 MHz – 1,344 MHz	4,096 MSps
Mid	1,344 MHz – 2,368 MHz	2,560 MSps
High	2,368 MHz – 4,032 MHz	4,096 MSps

The UWB system consists of a cryogenically cooled feed, orthomode transducer and LNAs followed by a "warm" RF electronics rack that contains amplifiers, variable attenuators and the three band-bass filters for the three bands indicated in Table 1. The three dual-polarization signal pairs from the RF electronics rack are sampled directly by six high-speed ADCs that are locked together to ensure synchronous sampling of the three separate bands. The architecture of the UWB system departs from conventional designs in that there is no intermediate analog conversion system and that the ADCs are located in an RF-tight cabinet adjoining the warm RF electronics which is mounted on the back of the receiver Dewar at the antenna focus.

The ADCs provide a serial JESD-204B data streaming interface which permits transport of the sample data over several single-mode optical fibers from the focus cabin to the remotely located and RF shielded back-end processing hardware. This not only avoids the dynamic range issues associated with RF transport over fiber but also permits effective mitigation of any RFI generated by the ADC electronics. The ADC data streams pass into a first-stage real-time DSP system based on Field Programmable Gate Array (FPGA) devices that channelize the data into 128 MHz sub-bands and stream them via a network switch to a cluster of GPU nodes for final astronomy processing pipelines.

In this presentation we provide an overview of the architecture of the Parkes UWB system with particular emphasis on the ADCs and FPGA real-time DSP.