The Fly’s Eye: Instrumentation for Detection of Millisecond Radio Pulses

Abstract

We present the design, construction, deployment and testing of the “Fly’s Eys,” an FPGA-based fast readout spectrometer designed to detect and elucidate powerful dispersed radio transients using the Allen Telescope Array (ATA). The Fly’s Eye instrument processes 44 independent signal paths, each with a bandwidth of 209 MHz, and produces 1.328-channel (8 bit/channel) spectra, accumulated for 5 ms, to give a total data rate of 32 Gb/hour. A hexagonal close-packed antenna-pointing configuration yields a maximum total field-of-view of approximately 198 square degrees at L-band.

The Fly’s Eye has been successfully installed at the ATA, and to-date approximately 500 hours of observations have been performed. We have detected three pulsars (B0329+54, B0355+54, B0950+08) and six giant pulses from the Crab pulsar in our diagnostic pointing data, and analysis of our close-packed hexagon paintings is currently underway.

System Architecture

The core of the Fly’s Eye Instrument is made up of eleven Center for Astronomy Signal Processing and Electronics Research (CASPER) Interim Break Out Boards (IBOBs), each of which is connected to two CASPER ADCs via the CASPER 2.0A IF interface. Each of the eleven IBOB / ADC systems in the Fly’s Eye process 4 of the 44 total inputs to the instrument. Four parallel time samples per input, acquired at four times the FPGA clock rate (816.008 MHz), are passed from the ADC to a digital down converter where the signal is mixed at 209.7152 MHz and then low-pass filtered to a bandwidth equal to 209.7152 MHz. The signal is then decimated to a sample rate equal to 209.7112 MHz. The resultant signal is complex, 8-bit and 8-bit Q, representing the signals from 104.8576 MHz to 314.5728 MHz.

The down converted and decimated digitized data is passed into a Polyphase Filter Bank (PFB) / Fast Fourier Transform block which together implements a 128 point 4 tap Polyphase Filter Bank on each of the 4 inputs (blanked internally as A, B, C, D). The frequency domain data is then passed into an equalization block which can selectively allow each frequency channel to be scaled by an individual coefficient. This allows a non-flat passed to be flattened digitally and provides for dynamic gain control over the pre-power spectrum. The final power spectra is output to an accuracy of 16-bit data.

As the conclusion of a spectra integration sequence, a user selectable time-boundary 8-bit portion of the accumulated spectra from each of the four channels on an individual IBOB is packetized via the PFGA PowerPC processor and output using UDP protocol over the IBOB’s 10/100Mb Ethernet port on a closed network. The packets from all eleven IBOBs are captured en masse on a single data collection machine. The total aggregate data rate for the entire system is approximately 7 Mb/sec x 11 / IBOB = 70Mb/sec.

The recent discovery by Lorimer et al. of a powerful (~30 Jy) and highly dispersed (DM ~ 375 pc cm

Motivation

The Fly’s Eye system was set up for automatic operation, although at the start of an observing session the operator needs to manually perform some setup and centering of the telescope array.

A set of scripts reads and sequentially configures the IBOBs as the beginning of the observation session (with parameters such as accumulation length, scaling coefficients and bit selection). A second set of scripts xxx the telescope appropriately (it sets the correct pointings and oscillator scaling coefficients and bit selection). A second set of scripts xxx the telescope appropriately (it sets the correct pointings and oscillator scaling coefficients and bit selection).

Instrument Control

The Fly’s Eye PowerPC Software Diagram

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Drift scan Fly’s Eye observations were conducted in campaign mode on weekends between February and April 2008.

Initial plan was for “fly’s eye” sky patch observing, a set of scripts xxx. A second set of scripts xxx the telescope appropriately (it sets the correct pointings and oscillator scaling coefficients and bit selection).

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