A Fast Pulsar Data Acquisition System

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V1.02 12 Jul 1996. Written by T. Hankins.


The data acquisition system described here is a versatile high-time resolution system that is useful for virtually all types of pulsar observing. It is designed for use at the VLA, the Arecibo and Green Bank observatories. The data are time stamped to the resolution and precision of the station standard or GPS clocks, so the system can be used for pulsar timing, and searching, correlator gating, spectral line studies, plus any other application where fast sampling of many channels is necessary. Care has been taken to include full polarization in all data sets and dual-frequency capabilities.

Overview

Data are sampled in three different time resolution regimes, ultra-fast (50–250 MS/s), fast (1–200 MS/s) and slow (0–200 kHz/s). For the first two regimes the received antenna voltages are recorded for later dedispersion and/or spectral analysis. The slow regime is for recording the detected and smoothed outputs of filter banks. Ultra-fast sampling is performed by digital oscilloscopes. The fast ADCs (FADC) are a set of custom printed circuit cards that allow quadrature sampling of two polarizations up to 200 MS/s, and two polarizations at two different frequencies up to 100 MS/s. The data resolution (2, 4, or 8 bits) is selectable. After sampling the data are packed into 16-bit parallel words. The slow ADC is a commercial 12-bit, 32-input VME card with an on-board buffer, capable of a maximum aggregate sample rate of 200 kHz/s. All three sampling systems can be run concurrently.

The ultra-fast sampling is intended primarily for studies of the pulsar emission mechanism where the fundamental time signatures of radio emission are to be determined. The fast sampling capabilities are used for emission mechanism and single pulse studies, precision timing, searching, and dynamic spectra. The slow ADC system is used for sampling of detected filter bank outputs in a manner similar to the Princeton-Dartmouth MKIII Timing Systems that have been used at Arecibo, Green Bank, Parkes and the VLA.

In addition to timing and low-resolution single-pulse studies it is used for obtaining real-time average pulse profiles which are essential for synchronous gating of the VLA correlator and for synchronous burst sampling of the two faster sampling systems.

For the ultra-fast and fast regimes the signals are either directly sampled or quadrature-mixed to baseband, filtered to reduce aliasing, then sampled by digital oscilloscopes or the fast ADCs. The digital data stream from the FADCs is passed through four 16-bit wide EDT CD-60 interfaces to a Sun Ultra 450 computer with 16 internally mounted 73-GB SCSI disks attached to four independent SCSI controllers. A dual-processor Linux-based computer is used as a 2-4-TB Gigabit network-attached RAID system for data archiving and offline processing. Data are saved on 200 or 250-GB IDE disk drives. The systems are controlled by a dual-processor Sun Sparc 20 which is connected by a private 10-Base-T Ethernet to a Motorola MVME 147SA-1 computer in a VME chassis. The Motorola CPU card controls the VME Timing Card and the slow ADC cards, and transfers the data to the Sparc 20 for display and archiving. The Timing Card provides Doppler-shifted sample rates and pulsar-synchronous gate signals for the ADCs, and it provides the time-of-day to the control computer for data time-tagging and event sequencing. The Local Oscillators, Baseband Mixers, Test Noise Generator, GPS receiver and Fast ADCs are controlled by GPIB and serial lines from the Sparc 20. mixing and sampler reference frequencies.

The system is designed to be remotely operable via the Internet. However, archiving of the fast data requires hands-on intervention for hot-swapping disk drives. The system is mounted in robust shipping containers for easy transport to other observatories.

A system block diagram is shown in Figure 1.

The system is designed to use standard software and bus structures and with as few custom components as practical to allow future expansion and extension as scientific needs develop and further funding becomes available.