Supplement to *J. Astrophys. Astr.* (1995) **16**, 239–242

A Digital Signal Pre-Processor for Pulsar Search using Ooty Radio Telescope

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Abstract. A fast digital signal processor has been designed and built for observation of pulsars and for pulsar search. This processor obtains spectral information over a bandwidth of 8 MHz (256 channels) every 256 μsecs. In this paper, we describe the design of this processor and present some test observations made with the Ooty Radio Telescope.

Key words: Pulsars—instrumentation.

1. Introduction

A digital signal processing instrument suitable for pulsar observations and survey using the Ooty Radio Telescope (ORT) has been realised. The ORT consists of a phased antenna array operating at 327 MHz with a beamwidth of 0.2 sq. deg. and uses mechanical steering in hour-angle and electronic phasing for a required declination. The receiver noise temperature is about 100 K. A SSB receiver with 8 MHz bandwidth provides the video band used for our digital signal processor.

2. Design philosophy

The design philosophy adopted in this excercise is aimed at reducing the cost of the machine while retaining flexibility and operational simplicity. Shortcuts to extensive, high-speed computations have been provided through the use of lookup table approach. At places where lookup table approach is not appropriate, dedicated logic has been designed, and programmed into Erasable and Programmable Logic Devices (EPLDs) which have the desired advantages. In addition, their use makes it possible to design the entire machine using only 2 layer PCBs and reduce the development time substantially.

A PC/AT is used for general control and for configuring the machine in a user selected mode. The choice of a PC/AT to setup the machine is due to the large software base available under MS-DOS in addition to the hardware flexibility.

3. Hardware description of the machine

3.1 *Digital front-end*

The digital front-end for this machine consists of an A/D convertor which samples the baseband signal at Nyquist rate and feeds them to a FFT engine. The FFT engine

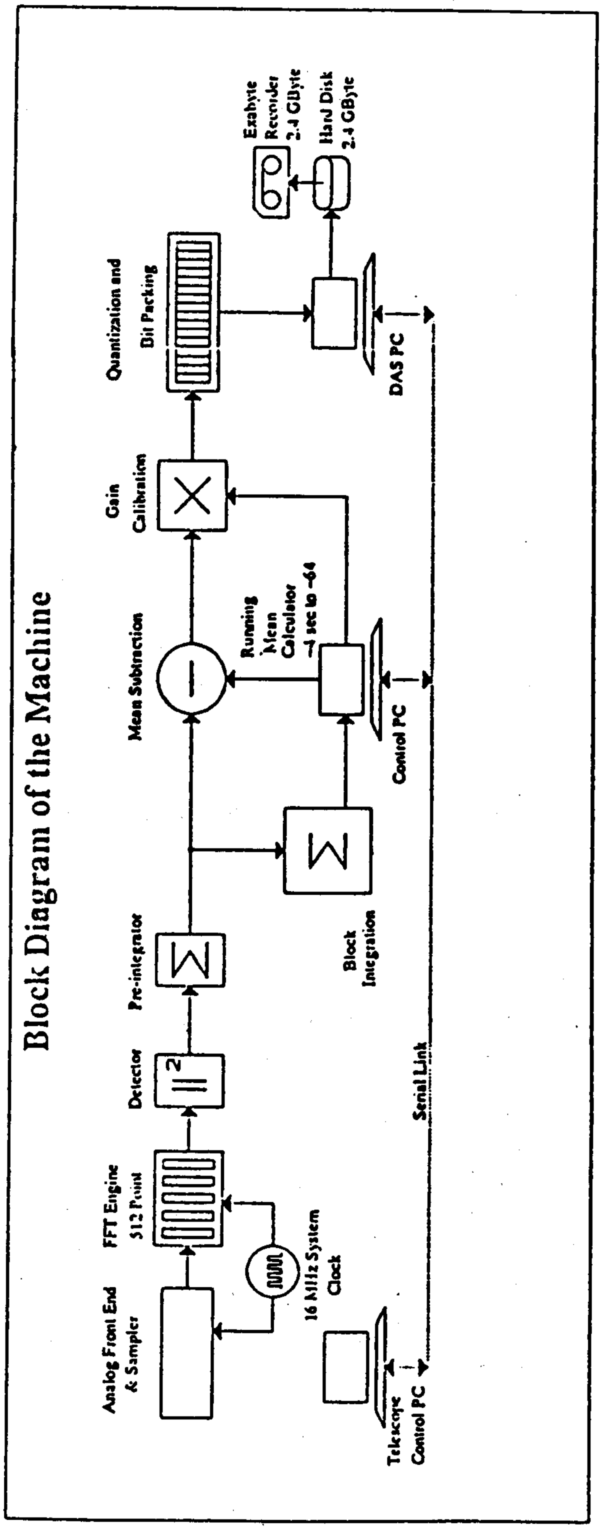

Figure 1. Block diagram of the machine.

produces an output over 256 spectral channels which are sent out serially. The FFT card is based on VLBA ASICs.

3.2 *Search pre-processor*

This is based on a part of the design of pulsar instrumentation to be built for use at GMRT (Deshpande 1989). The complex numbers representing the voltage spectrum produced by the FFT engine pass through lookup tables for conversion to a power spectrum, followed by a programmable pre-integrator, which pre-integrates between 16 and 256 samples. The pre-integrated values from each of the 256 channels are used by a control PC/AT which computes running mean over ≈ 4 sec to ≈ 64 sec. This running mean in subtracted from the pre-integrated data and the difference is quantized to 1 bit. Such quantization, although it worsens the sensitivity by a factor of 0.8 (Biggs, Lyne & Johnson 1989), helps reducing the effective data rate. A 2-bit quantization option is also provided and in this mode a lookup table based gain calibration unit is programmed by the same PC with scale factors obtained from the running mean. The quantized bits are then packed into 16-bit words and recorded onto a 2.4 GBytes hard disk drive of a PC/AT-based data acquisition system (DAS, built to handle data rates upto 128 KBytes/s). The DAS is equipped with FIFO buffer to accommodate the seek-time latency of the hard disk. The data can be periodically backed up onto an 8 mm video tape using an Exabyte Video Recorder. All the modules run through automated diagnostics while being setup by the control PC.

A set of serial links have been developed between the Control PC, the DAS-PC and a PC/AT positioning the telescope. This link has automated observational procedure substantially. Also, the total power measurement and the bandshape are recorded for calibration. A block diagram of the entire receiver is shown in Fig. 1.

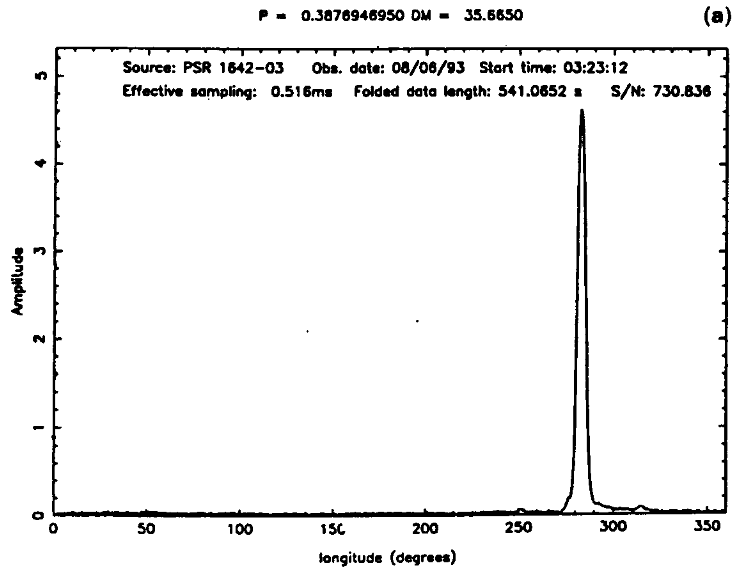

Figure 2.

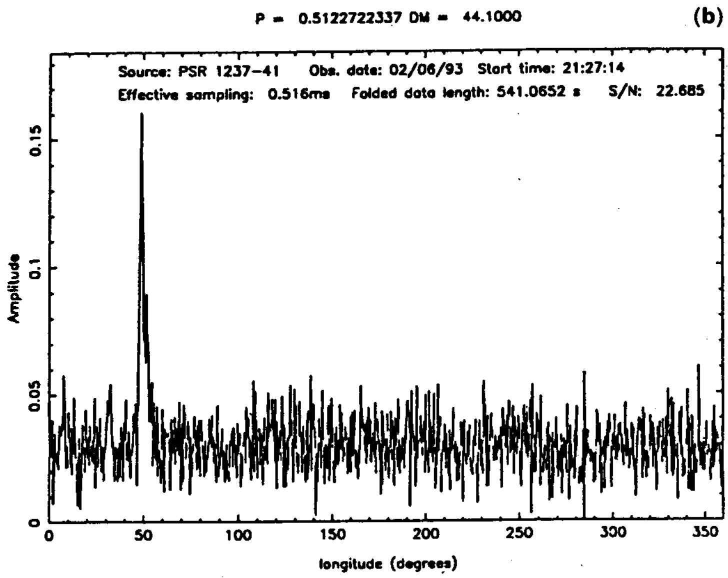

Figure 2a & b. Pulsar profiles observed using the machine.

4. Results

Several known pulsars have been observed using this instrument. Some of the profiles of the observed pulsars are shown in Fig. 2.

References

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Deshpande, A. A. 1989, *Pulsar Instrumentation for GMRT* An internal report, Raman Research Institute.