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Polarimetric spectrometer for Italian Radiotelescopes

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Abstract. A new spectrometer has been designed and tested at the Radioastronomy Laboratory of Arcetri Astrophysical Observatory. It provides a resolution of 4096 spectral points over a bandwidth selectable between 0.5 and 125 MHz. It can analyze up to 8 independent signals with full polarimetric capabilities. This spectrometer can be used as back–end for a 7 channels double polarization radio receiver,working in the frequency range 18–26 GHz, implemented in the same laboratory.

Key words. Spectrometer: FFT – Spectrometer: polarimetric – Filter: polyphase

1. Introduction

A FFT spectrometer has been designed and tested in the Radioastronomy Laboratory of the Arcetri Observatory and has been recently used for H_2O maser observations on the Medicina Radiotelescope. It has been conceived as a prototype back–end for a 7 channels double polarization 18–26 GHz receiver implemented for the European project FARADAY. The molecules observable at these frequencies,including the water maser emissions, show complex spectral patterns. For these reasons a modern spectrometer should allow different transitions in the receiver band to be simultaneously observed at high resolution. These requirements can be matched with an instrument that provides a large number of spectral points, allows simultaneous observations of several points in the sky (multi–beam receiver) and simultaeous observations at different resolutions, using several input channels. These channels can also be used to synthesize wider bands. Stokes parameters computation can be performed on the two signal polarizations. The spectrometer must provide also very fast reading times and no dead acquisition times between consecutive spectra, for on–the–fly mapping observing mode.

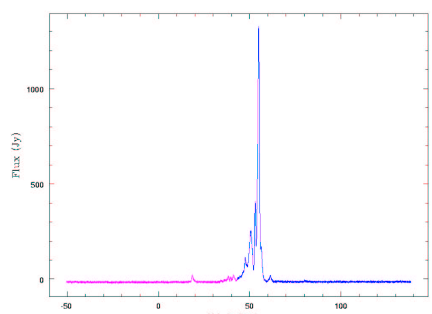

Fig. 1. SFR W3(OH) – Bandwidth 15.625 MHz – spectral resolution: composite, 2 x 4096 points overlapping spectra

All these topics are implemented on a very compact instrument realized with a matrix of

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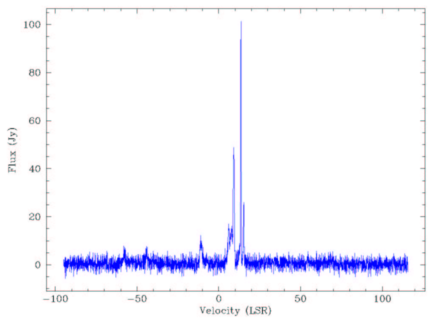

Fig. 2. SFR ON1 Bandwidth 15.625 MHz – spectral resolution 4096 points

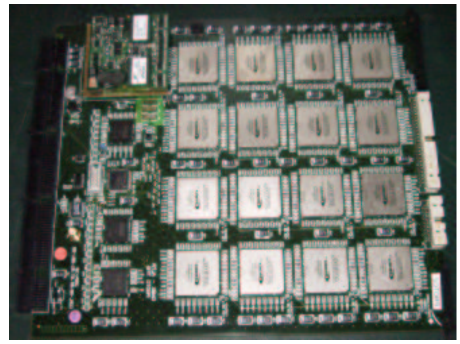

Fig. 3. The 4 x 4 FPGAs board on which the final version of the polarimetric FFT spectrometer will be implemented.

FPGAs (Field Programmable Gate Arrays) arranged in a modular way. Design parameters are memorized in a configuration file and specified using a high level language. In that way design components can form software libraries that are indipendent from hardware devices, allowing the re–utilization of hardware for different applications.

Instruments of this kind are now used on Medicina and Noto radiotelescopes, so this topic is useful for several designs porting, each one for a particular astronomical application.

2. Instrument description

Our spectrometer is composed of up to 16 identical modules organized in pairs. Each module provides a resolution of 4096 spectral points over a bandwidth selectable between 0.5 and 125 MHz.The desired input bandwidth is selected by a digital programmable filter with decimation factors betweeen 2–256. A digital polyphase filter before the FFT block improves channel insulation. The FFT processor operates on two indipendent channels and computes two real time complex 4096 points Fast Fourier Transforms on two indipendent channels. The squared module of the FFT outputs is computed to obtain the power spectral density. The cross products of the two polarizations are also computed for Stokes parameters evaluation. The integration of consecutive frames is realized with two indipendent memories, in order to read the previous integration while the next one is in progress.

Each module pair can be used to analyze a double polarization channel of a multi–beam receiver, or a indipendent spectral transition. Several modules can be put side by side to syntesize larger spectral bandwidth (fig.1).

3. Instrument implementation

A first implementation has been tested in Medicina Radiotelescope with H_2O maser observations and two observed spectra are reported in the figures 1 and 2. It has been implemented on two FPGAs contained in a board and only one input channel given by an ADC converter at 125 MS/s.
A second implementation is currently being developed. Main improvements are: 8 channel inputs, ADC converters at 250 MS/s and a board (fig.3) containing 16 FPGAs.

It will analyze up to 8 indipendent signals with full polarimetric capabilities. Two of this spectrometer will implement a complete back–end for the 7 beam double polarization receiver named above.

References

Comoretto G., Nesti R., Russo A., Palagi F., 2006 Arcetri Technical Report 4/2006 “A multichannel Spectrometer – Design Study”

Comoretto, G., Russo, A. 2007, Arcetri Technical Report 2/2007, “Software di Comunicazione con il Correlatore Altera”