A high performance solar radio observation system in terrible RFI environments for existing telescope

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Abstract:

For the solar radio observations, scientists usually come cross some strong RFIs (Radio Frequency Interferences) producing some invalid observation data. In the past, we had to give up some badly influence bands. Nowadays, we can decrease the RFIs' influences by using advanced circuits, such as high dynamic range analog receivers, remote gain or attenuation controlling software, high performance ADCs and so on.

In this paper, we will introduce a new solar radio observation system in Yunnan observatory's 10 meter solar observation system for 800-975MHz observation band which was given up because of some strong RFIs in the past. This new solar radio observation system can adjust the gain from -25dB to +35dB by remote software through RF(Radio Frequency) and MF (Medium frequency) attenuators. Based on advanced FPGA processor we can achieve high spectral resolution of about 30 KHz/channel and high time resolution of about 34ms. This system can easily improve the capability of old solar radio telescopes for adding abandon bands in

1. Introduction

Solar radio observations, especially in the frequency bands from decimeter to decameter are important to research the fields of solar physics, space weather, and plasma physics .But these bands are widely used for wireless communications, Frequency modulations, and some wireless remote control equipments and so on. These radio frequency interferences sometimes badly influence observation systems (Ryabov et al., 2010). In some time, these RFIs may lead the analog receivers overflowed. In the past, the observation systems had to give up some badly polluted bands for making sure that the systems can extract useful information from the signals.

A 10-meter solar radio telescope working in the decimeter wave bands in Yunnan Astronomical Observatories in the east suburb of Kunming city (102°.79 N, 25°.02 E，Figure 1) had to give up the band of 800-975MHz for strong RFI of GSM(Fu et al., 2004a, b).

Fig 1. The 10m solar radio astronomy located at Kunming city

But fortunately, with the electronic development, there are more and more advanced microwave and digital departments appearing on the markets. Such as the high dynamic and low noise amplifiers, HTS (High-temperature superconductor) filters, high sampling speed ADCs (Analog to Digital Convertors), high performance processors, and so on. Based on these departments, we can effectively get wider dynamic range and reject some RFIs, reduce the system noise and promote the time and spectral resolutions (Benzet al., 2005, Dong, L. et al., 2009).

So we can recover the given up observation bands on the existing telescope by taking advantage of these departments. Based on this idea, at first we don't need to build a new telescope or find a perfect radio environment site; in another hand, we can quick recover the given up bands with limited fund.

In this paper, in Sect.1 we will introduce the radio environments of 800-975MHz band in Yunnan Astronomical Observatories and the analog receiver's structure. In Sect. 2, we will introduce the digital departments' structure and processing pipelines. At last, we will give a review of the software.

2. Analog department

2.1 RFI environment

The 10m solar radio telescope has four existing observation sub-bands: 625MHz-800MHz, 975MHz-1150MHz, 1150MHz-1325MHz, 1325MHz-1500MHz and the 800-975MHz sub-bands was given up because of RFIs (Fu et al., 2004a, b).

Before analog receiver designing, we monitor the RFI situation at point A (see Figure 3):

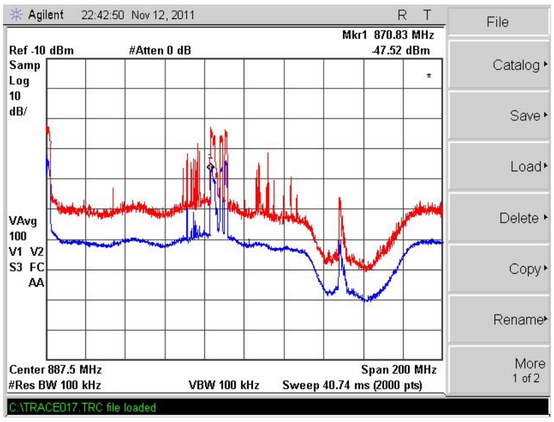

Fig.2 The radio frequency environment range from 800 to 975MHz in YunNan observatory in Kunming city

There are several strong RFIs in 800-975MHz sub-band. Based on this graph, we put forward an new analog receiver and control the RF and MF gain by remote software without effecting the performance of existing one.

1.2 Analog receiver structure

Without affecting the existing receiver's performance, we use a power divider at point A for dividing the signal from antenna into two parts, one is sent into new receiver and the other is sent into the existing one:

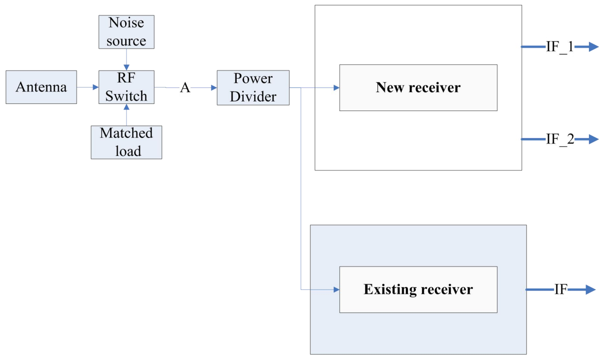

Fig 3.The relationship between new receiver and existing receiver

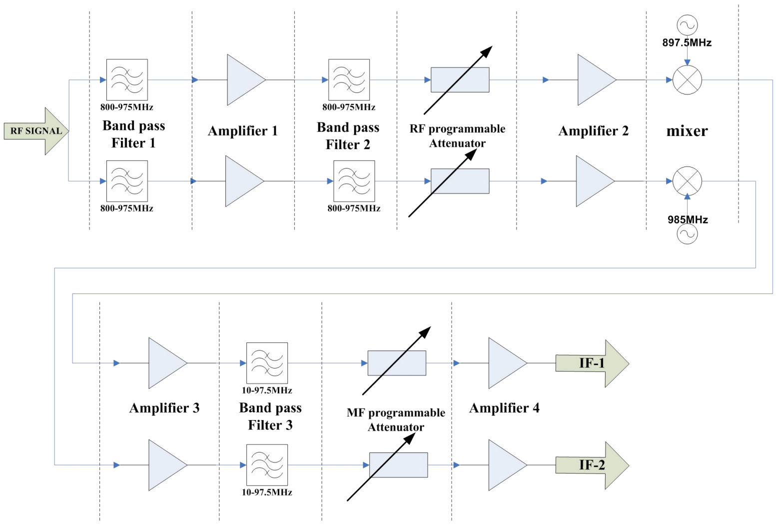

Fig 4.The structure of analog receiver

We divide the 800-975MHz band into two parts for decreasing the ADC's sampling by two sub-bands: 800 ~ 887.5MHz and 887.5 ~ 975MHz with independent filters, amplifiers and mixers (see table 1 and table 2). And at the same time, there are two programmable attenuators: RF attenuator and MF attenuator in each analog path. By these programmable attenuators, we can adjust receiver's total gain by software when there are some more strong RFIs (see Figure 6).

Fig5. The control software interface

2. Digital Departments

The system configuration is shown in Figure 6. The 800-975MHz analog signal, which is received by the 10m antenna, is down converted to a 10-97.5MHz analog signal by the analog down converter. Then this signal is sampled by A/D converter and goes into the FPGA. The real-time spectral analysis is executed by FPGA, and then the result is sent to a remote PC via Gigabit Ethernet using UDP protocol. PC software is using developed by C#, and it can perform data integration, display and storage tasks The core of the system is the FPGA-based signal processing. It includes windowing, FFT, power calculate, logarithm, superimpose, and Ethernet transport by UDP protocol. Some key parameters of new spectrometer and existing one are shown from table 3 and table 4.The structure of the arithmetic is shown in Figure6.

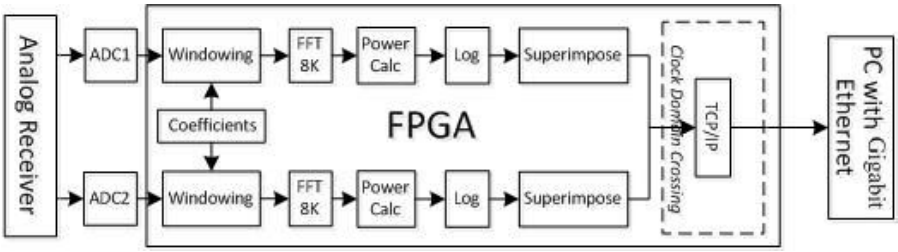

Fig6. FPGA Signal Processing Section Structure Diagram

The observation software interface is shown below (see Figure 7):

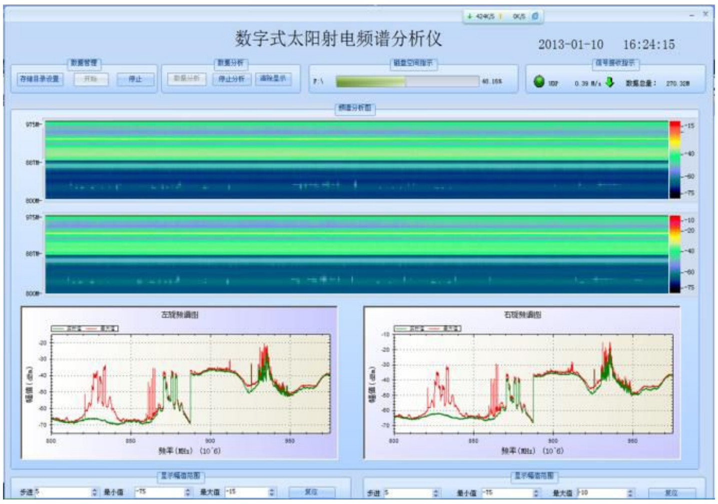

Fig 7. Observation software interface

From the interface of observation software, we can get spectral waterfall graphs in real time. At the same time, we can easily start or shut off spectrometer by several keys in the panel. In another hand, we can monitor the net working status. At last, all of the processed data is restored in hard disk.

3. Acknowledgments

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