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Virtual Instrument for FPGA based Spectrum Analyzer

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ABSTRACT

We report the design and operation of a Virtual Instrument (VI) system based on LabVIEW for spectrum analyzer experiments. This system achieves synchronous control of equipment and acquisition of real-time data communicating with a single computer via USB or RS232 serial port. The reported VI system can also accomplish data display, saving, and analysis, and printing the results. The VI system performs sequences of operations automatically, and this system has been successfully applied to obtain the FFT of Applied signal (from Antenna or Signal generator) connected to Serial port via FPGA. The reported VI system opens up new possibilities for researchers and increases the efficiency and precision of experiments. The design and operation of the VI system are described in detail in this paper, and the advantages that this system can provide are highlighted.

Keywords–FPGA, LabVIEW, Spectrometer, Spectrogram, Spectrum analyzer

I. INTRODUCTION

Spectrum analyzers are widely used within the electronics industry for analyzing the frequency spectrum of radio frequency, RF and audio signals. Spectrum Analyzers find wide applications in vibration analysis, speech analysis, harmonic measurement, etc. [1, 2] There are different types of Spectrum Analyzers in use. Among them, FFT Spectrum Analyzer, which is suitable for analyzing signals containing wide range of frequencies, is implemented on PC platform using LabVIEW [3].

Looking at the spectrum of a signal they are able to reveal elements of the signal, and the performance of the circuit producing them that would not be possible using other means. Most laboratories develop homemade programs for their experiments using different programming languages, such as Visual C++, LabVIEW, Visual Basic, or Turbo Pascal, but text-based languages have the shortcomings of long developing cycles and difficulties in maintenance and expansion [4]. NI LabVIEW 2009 (National Instrument Inc., USA) is a graphical programming tool which can be employed to develop sophisticated measurements [5–7] and control [8] systems using intuitive graphical icons and wires that resemble a flowchart instead of written lines of text [10–15].

In this paper, a virtual instrument system based on LabVIEW is developed to provide a front end to an FPGA based spectrum analyzer implemented to test and characterize an RF antenna designed to work in the low frequency range of 500 KHz to 20 MHz [17]. An application of developed VI in the examination of 500 KHz to20MHz is shown in this paper. Simple modifications for adapting this program to different setups are also illustrated. Furthermore, it achieves real-time data processing and monitoring of individual instruments. LabVIEW is preferred for this experiment because it is simulation tool so we can analyze data without hardware.

II. OVERVIEW OF FPGA BASED SPECTRUM ANALYZER

FFT based digital spectrum analyzer named as FFT Spectrometer has been designed and implemented on Virtex 5 FPGA for low frequency observation below 20MHz. Fig.1 Outlines the various blocks used in the FPGA based spectrum analyzer design. Input signal is digitized using analog to digital converter (ADC) and the spectral analysis of digitized sampled data is performed by computing FFT algorithm. UART interface has been developed for testing and debugging of FPGA based design. With the help of LabVIEW VI serially received data is displayed as well as stored in the excel file. Different operating mode of FPGA based system is also controlled by sending command through LabVIEW VI.

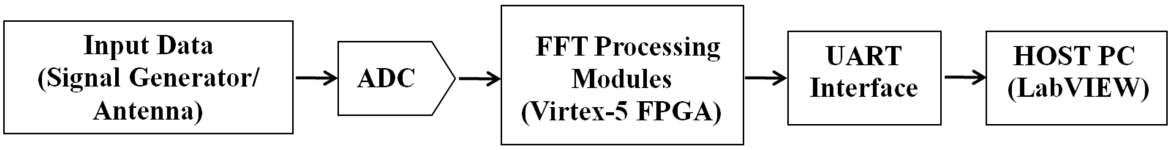


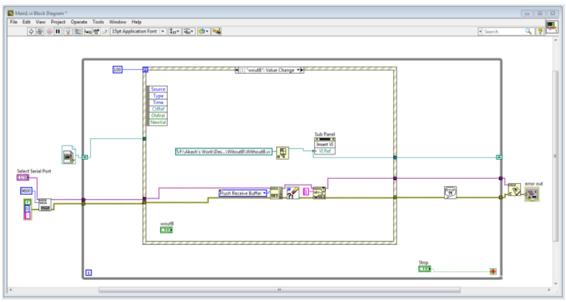
Figure 1 : Block diagram of System

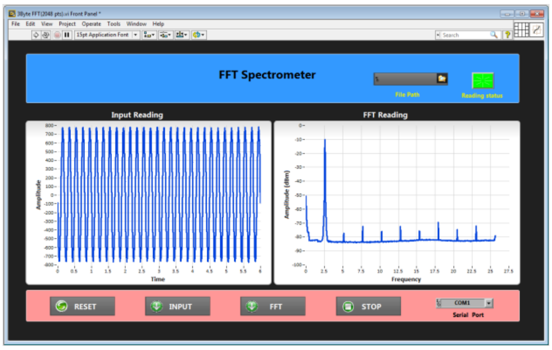
III. FRONT PANEL DESCRIPTION OF FFT SPECTROMETER VI

LabVIEW VI allows the control of the FPGAs based system as well as acquisition of real-time data via RS232 serial communication protocol. The following fig.2shows the Main Front Panel, which has options through which FPGA system can be controlled**.** The Main front panel of FFT Spectrometer consist of four mode control button they are as follows :

- One Shot Data Mode
- Continuous Data Mode
- Dual Channel Mode
- Spectrogram Mode

Figure 2 : Main Front Panel of FFT Spectrometer





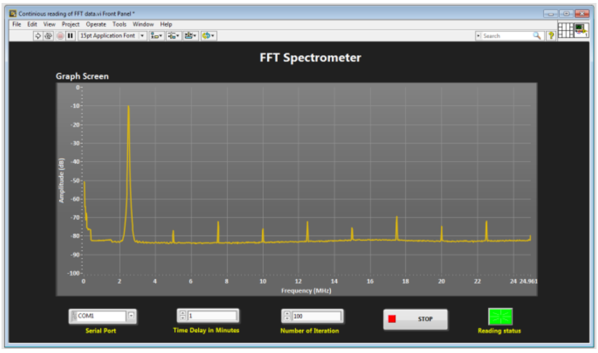
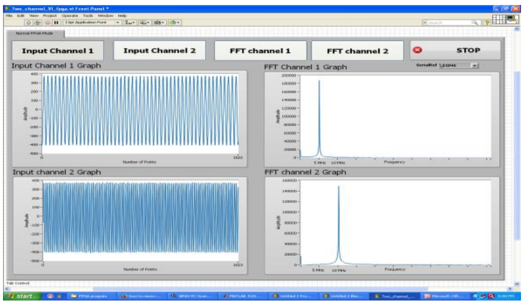
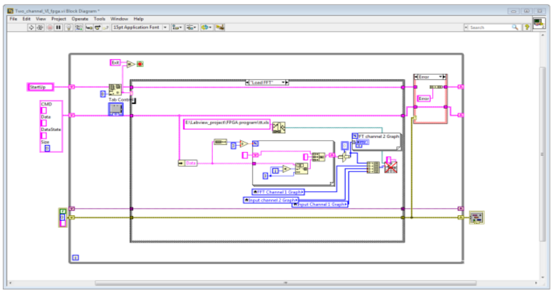


Figure 3 : Block diagram of FFT Spectrometer

Figure 4 : One Shot data Mode **Figure 5 : Continuous data Mode**

In the One Shot Data Mode the data is acquired once. This mode is used to take the data at that instant of time. In this mode the one shot data confirms the successful acquisition of the data by the system. Therefore this mode can be considered as the Test Mode. The Continuous mode is used to acquire the data for N-number of times by giving the Number of Iteration provided with some Time delay in Minute. The first and second mode are mainly

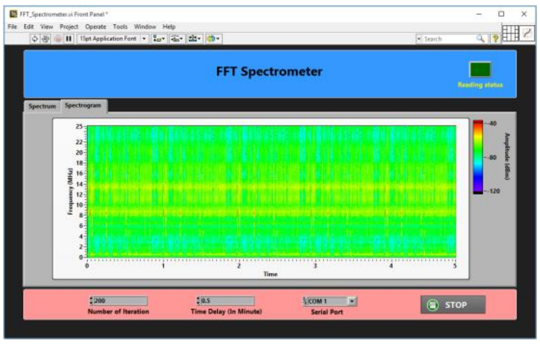


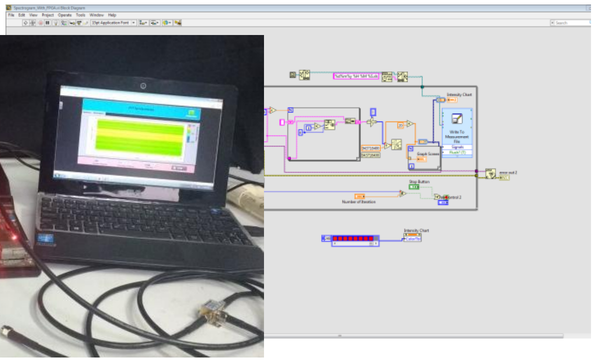


is used for single channel acquisition. The third mode provides the provision for Dual Channel data acquisition. With this mode two channel data can be acquired and its FFT can be seen on the Spectrum display.

Figure 6 : Two Channel data acquisition Mode **Figure 7 : Back Panel of Program**

The spectrogram display is the one of the best way to measure frequency, occupied bandwidth and relative signal strength; also need to find out how often a signal is changing over the time. The spectrogram provides important information as it can show how often a signal is present, and indicates if the operating frequency is changing over the period of time. These two pieces of information are important for identifying the variation in the particular radio emission. With the Spectrogram it's possible to make accurate assessments of the type of radio emitter that is being analyzed.





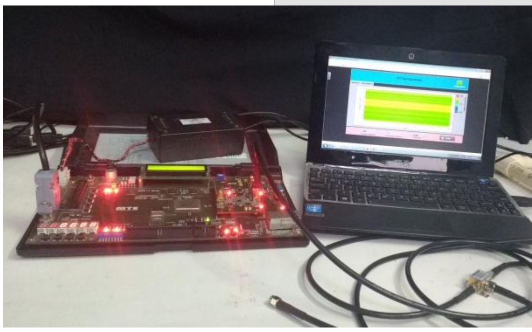


Figure 8 : Spectrogram Mode front Panel

Figure 9 : Back panel of the Program

The Spectrogram display is shown in Fig. 8.The frequency is represented on the y-axis. However, the x-axis represents time, and the power (amplitude) is expressed by the color. The spectrogram provides visualization of all the frequency and amplitude activity across the chosen span. The amplitude (or energy) of a particular frequency at a particular time is represented by the third dimension, color, with dark blues corresponding to low amplitudes and brighter colors up through red corresponding to progressively stronger amplitudes.

IV. EXPERIMENTATION AND TESTING

The VI designed, was tested with the help of the FPGA along with RF Signal Generator (Agilent N9310A and Spectrum Analyzer (Agilent N1996A).LabVIEW VI was set up to access the digitized as well as processed data from the FPGA. Initially, the system was tested by applying different signals with the help of signal generator varying the amplitude as well as frequency of the signals and the results were compared with those obtained from the Agilent spectrum analyzer.

LabVIEW VI is used to create the user interface and control operations of the system. One Shot mode is used to test and debug the system. It provides features including, Input signal display, Output FFT display. The LabVIEW program has the feature to store the data automatically into the Excel sheet after the completion of data acquired by the FPGA system which reduces the user efforts. Fig.10 shows Single channel spectroscopy experimental setup. RF Signal Generator (Agilent N9310A) is used to provide Signal to the FPGA and Spectrum Analyzer (Agilent N1996A) displays its FFT. Spectrum analyzer and LabVIEW both show similar output. The Fig. 11 shows the comparison of Spectrum Analyzer and LabVIEW data acquired by FPGA when input is taken from Antenna.

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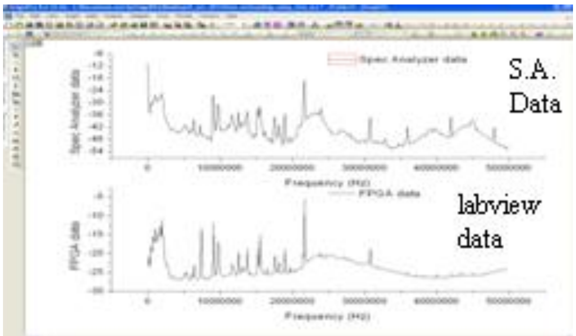


Figure 10 : Single channel Spectroscopy experimental setup

Figure 11 : Comparison of FFT by FPGA (or LabVIEW) and FFT by Agilent N1996A Spectrum Analyzer FFT

Following Fig. 12 Shows the Experimental set-up in which input is taken from Antenna and its Spectrogram is observed on the LabVIEW FFT Spectrometer.

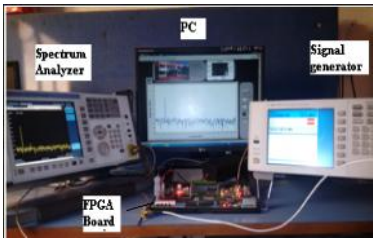
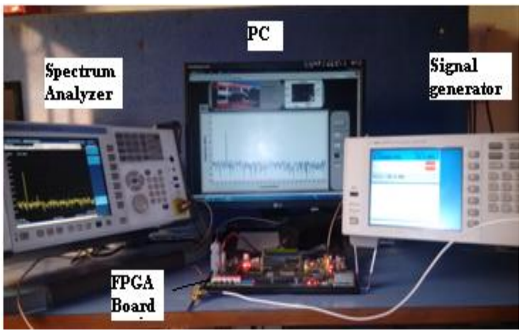


Figure 12 : Experimental Set-Up for Spectrogram

V. CONCLUSION



The Virtual LabVIEW spectrum analyzer has advantage over any Hardware spectrometer like more user friendly environment, fast speed, astronomically take reading over time, more storage memory and in one shot we can see output. It is cost effective as compared to the Real Spectrum Analyzer Instrument.

VI. ACKNOWLEDGEMENTS

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