International Conference on Recent Innovations in Science, Engineering & Management
R.R. INSTITUTE OF TECHNOLOGY, Bengaluru (India)
10th - 11th May 2019 www.conferenceworld.in ISBN : 978-93-87793-87-3

Pc-Based Multi-channel Oscilloscope Using Arduino

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Abstract-Oscilloscopes are the most useful test instruments for electronics professionals to verify that their designs would work as expected.The door for "virtual instrumentation" has opened with a key which paved a path for integration of personal computers (PCs) with present day measurement and instrumentation.

In recent years, an additional feature of PC connectivity has been added to digital storage oscilloscopes (DSOs) such that signal can be stored in the PC for later analysis.However, with these increasing features,oscilloscopes have become more expensive and less accessible for undergraduate electronics students.These complications of standalone oscilloscopes are overcomed by PC-based oscilloscopes with their compact size,low cost and ability to do offline analysis.The main advantage of PC-based oscilloscopes are that they can be used to capture signals up to 5kHz.

The heart of these oscilloscopes is "Aurdino Board". Arduino is a fusion of three critical elements: hardware, software, and community. It is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software and this environment makes it easy to write code and upload it to the i/o board. It reads values from its inbuilt analogue-to-digital converter (ADC) and pushes these to the PC via USB port.Hence, this device acts as the front-end to plot input signals as waveforms on your computer screen.This device has been designed as a simple plug-in board to be integrated to any PC parallel port thus eliminating the requirements of multiple, expensive, digital oscilloscopes.

Keywords-*Virtual Instrumentation, Digital Storage Oscilloscope,ArduinoBoard,Personal Computer, Analog to digital converter.*

I . INTRODUCTION

Oscilloscope is enlightened as one of the most advantageous instrument available for testing the circuits[8]. It displays the signals at different points in the circuit. One way to examine an electronic system is to observe signals at the input and output and check the operating conditions of each system block. Traditionall[1][2]y, signals were analyzed using electromagnetic oscilloscope graph which later was substituted by cathode ray oscilloscope for the purpose of getting higher bandwidth. Cathode ray oscilloscope is a hardware instrument which is based on Cathode Ray Tube (CRT)[6][7], designed to display voltage variations (periodic or otherwise).But they are expensive, bulky, and have difficulties on displaying low frequency waveforms. Hence they are replaced by Digital Storage Oscilloscope (DSO) .Digital Storage Oscilloscopes are widely used in recent market environment because of their higher bandwidth[3][4].The most attractive feature of this type of oscilloscopes is they are capable of evaluating both analog and digital signals. Another enticing feature of digital storage oscilloscopes is that the captured data can be adequately used for future analysis Inspite of having these additional features , these digital storage oscilloscopes are a bit more expensive .in today's educational institutions ,especially in electronics engineering field oscilloscope play an important role for analyzing the circuit performance. Due to the expensive costs of oscilloscope these are less accessible to the undergraduate novice students[5].moreover ,digital storage oscilloscope cannot be carried out easily from one place to another as it was bulky in nature. To overcome all these disadvantages of digital storage oscilloscope , a portable pc based multichannel oscilloscope was developed[1][2].the main theme of this system is interfacing personal computer(PC) with a Aurdino board to develop a portable oscilloscope. This oscilloscope can be carried out with much ease and was affordable to the undergraduate students to evaluate the performance their circuits.

PC BASED VIRTUAL IMPLEMENTATION

The instrumentation industry is heading steadily and rapidly towards the direction ofvirtual instrumentation. Virtual instruments are centered on a PC,embedded with specialized hardware to link it to the devices it must measure/control. This hardware typically includes plug-in boards for digitizing a signal directly or for controlling stand-alone instruments. Virtual instrumentation is known for its flexibility, interchangeability and low cost. Celma et al. [1] conferred an idea behind the development of a PC- based spectrum analyzer suitable for use in undergraduate laboratories. They identified that the requirements of such a data acquisition system are not very high in view of the limited range of signals encountered in undergraduate laboratories. Chickamenahalli et al. [2] developed an undergraduate research project that involved the interface of a HP digital oscilloscope to an IBM PC using National Instruments' General Purpose Interface Board.Smith etal.[3],[4]in their papers explained about setting up of a simple DSO integrated with a printer/plottersystem for quick reproduction of the signal. However, they were suspicious about the bench-space requirements for such a scheme involving the DSO, printer/plotter ,and the PC.This discovery led to the concept of integrated DSO-PC-based aurdino system described in the present paper, one sufficient and affordable for most undergraduate-level laboratories.

The present paper mainly contributes in developing a fully functional, PC-based oscilloscope with associated modules of data acquisition hardware ,software ,interfacing , and graphical user interface (GUI).Processing 3 offers a versatile tool for developing a PC-based multichannel oscilloscope.this is an open source IDE which can be easily downloaded and explored with attractive designs,Hence this can be easily afforded by undergraduate students. With the help of this IDE, the proposed system is intended to provide a low-cost, simple, yet effective solution for integrated multichannel data acquisition, display, analysis, and printing operations in an undergraduate laboratory. It make use of the conventional PC parallel port, interfacing circuitry costing less than US $10.00, and commonly used GUI development tool and other programming languages, such as Java and Turbo C. The system is excellently used in undergraduate laboratories for real-time applications and educational/ instructional purposes as well.

II. SYSTEM DESCRIPTION

Pc based multichannel oscilloscope system was broadly divided into two parts-software and hardware part.In this system arduino was interfaced with pc through a parallel port.The input signals are given to analog pins of the aurdino **.**arduino has inbuilt analog to digital converter which converts the analog signals into digital formats such that pc can read those signals The purpose of ATMEGA328 microcontroller is actually generating 16Mghz sampling frequency into ADC while receiving and transfer the digital data serially to the PC via USB connection. Micro controller was programmed in .hexadecimal form to achieve these functions and receive controls from PC. In addition to these, itperforms a two way communication between PC and itself. .An IDE that was built using processing 3 produces the oscilloscope scenario.the digital signals captured by pc were displayed on the PC's screen using this IDE.

III. HARDWARE DESIGN

The data acquisition system requires an arduino board
,potential divider circuit, voltage sensing card, **personal computer.** The designed data acquisition system was used to sense multichannel analog inputs and for converting them into digital formats before transferring them to the PC. The digital data is stored in the PC memory and the signal was displayed on the PC screen. The block diagram of the developed system is shown in Fig. 1.

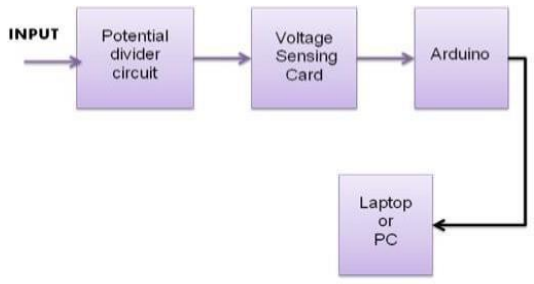

Fig 1 :Block Diagram

Potential divider circuit was used to convert an input voltage level down to 5V.This was primarily used to protect arduino from excessive high voltages.the signals are then taken as input by voltage sensing card which constantly monitors high operating voltages reaching arduino and prevents them from reaching arduino board.the output of voltage sensing card is given as input signals to arduino board.

Arduino processes these analog signals and converts them into digital signals using inbuilt analog-to-digital converter(ADC).These digitized signals were communicated to pc through serial com port.pc after processing the signals displays them on it's screen.The hardware design is chiefly intended to perform interfacing and input /output (I/O) functions.The system is capable of acquiring and displaying six signals at a time with an additional provision of data storage.

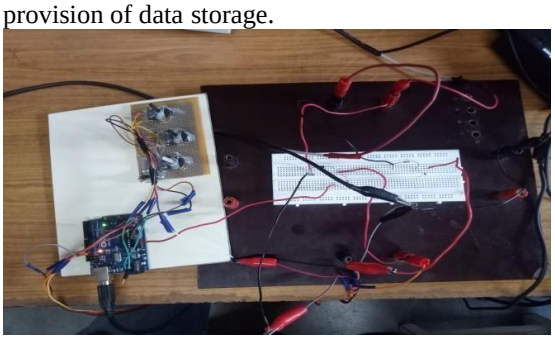

Fig 2:Hardware Prototype

IV. SOFTWARE DESIGN

A fully dedicated application has to be developed to control the data acquisition system.Pc based oscilloscope environment was created using two softwares-arduino IDE,Processing 3.This system make use of arduino IDE of version 1.8.9.Arduino was programmed to capture the given input signals ,digitalize them and send these processed signals to the PC through serial com port.The arduino tab for programming is as shown in figure 3

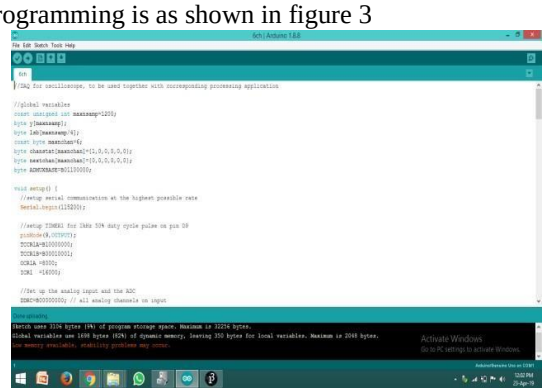

Fig 3:Arduino IDE

Processing 3 ide was a graphical user interface which was used to develop the environment of oscilloscope in personal computer(PC). The arduino program was interfaced with processing 3 IDE .the refined signals coming out from arduino was given to processing IDE which displays the signals on PC's screen as shown in figure 4

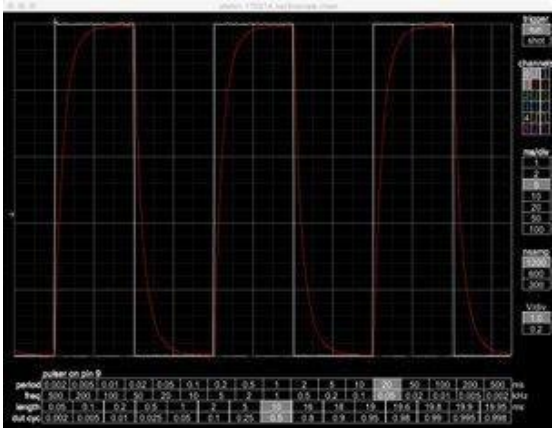

Fig 4:Processing IDE

Besides displaying the six real-time signals ,it allows the common functionalities of traditional oscilloscope like voltage scale changes,time scale changes along with the number of sample changes.

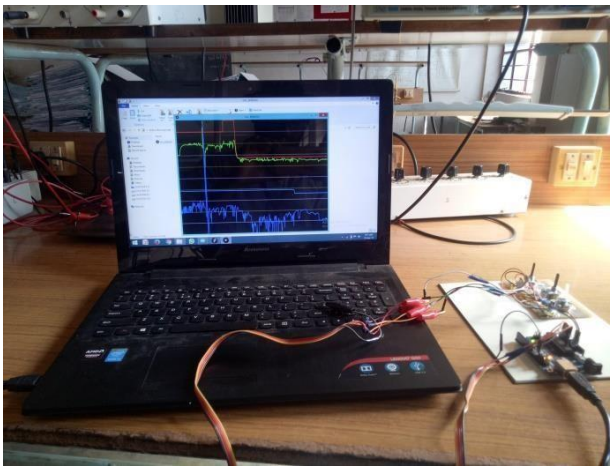

Fig 5:System Prototype

V. APPLICATIONS

The traditional display sytems are capable of displaying atmost two signals simultaneously .the system developed in present paper is capable of displaying six signals at a time.The added advantage of the developed system is it facilitates the user to disable the channels if required and to enlarge a particular signal for detailed analysis.

Apart from displaying the signals, it was very useful for undergraduate students and electronic professionalists in the following ways:

1) Enchances the knowledge of students and make them to implement innovative

projects.

2) This virtual instrument make users think of solutions to the issues thy faced while building their circuit.

3) Comparisions can be done based on the stored data in pc memory.

4) Arise interest in students towards virtual instrumentation.

V. RESULTS AND DISCUSSIONS

PC based multichannel oscilloscope was firstly simulated by using processing Debugger. A test signal generated from function generator is given as input signal to arduino which was then connected to PC through a USB connection, using the system hardware prototype.

The results are displayed in developed oscilloscope system was as shown in the figure 6

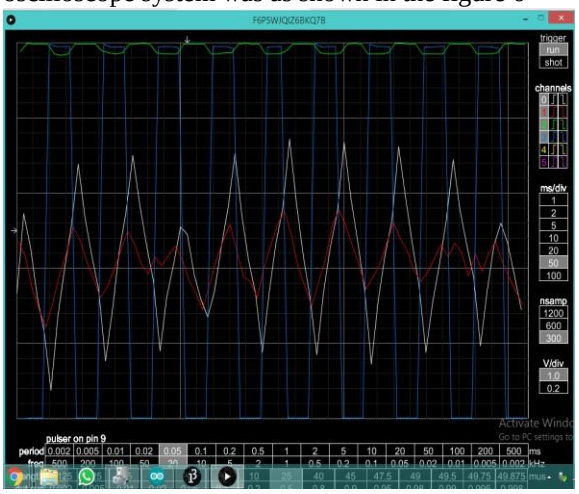

Fig6:Multiple waveforms displayed using developed oscilloscope system

VII. CONCLUSION

A low cost, portable, plug-in type PC oscilloscope is implemented based on the communication features of the PC parallel port.Hereby it is concluded that Arduino can be used as an Oscilloscope for displaying and analyzing waveforms. Arduino Oscilloscope also has the added feature of performing various operations on the applied input signals such as addition, subtraction etc.This helps the undergraduate students to analyze in a simple way and overcomes the drawbacks of the conventional CRO's.the hardware interface circuit developed makes the functioning of a oscilloscope much easier with few affordable electronics components.The Arduino software (IDE) used was easily available on the Arduino website and it is free of cost.The software developed was used to manage the acquisition, to represent the signals and post processing of the signal.The use of potential divider circuit protects the Arduino from over voltages or from getting damaged.

VIII. REFERENCES

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