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Android Based Digital Storage Oscilloscope

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Abstract- **A Digital Storage Oscilloscope stores and analyses every signal digitally rather than using analogue techniques. Oscilloscopes which are currently available in market like Cathode Ray Oscilloscope (CRO) or Digital Storage Oscilloscope (DSO) are expensive, consume more power and are bulky. Many portable devices, such as tablets and smartphones, support the Android Operating System and are capable of composing a Graphical User Interface(GUI) for a DSO, through an application. If a DSO application is designed, the desired waveform can be seen directly on mobile. The Android Operating System (OS) is constantly attaining more interest of developers throughout the globe. Android based DSO presents the design and implementation of a low cost, portable, light weight, low power, single channel DSO. Signals having frequency between 0-100Hz and amplitude 0-10V can be measured. It has 3 modules: Advanced Virtual RISC (AVR) interface, Espruino (ESP) module and Android application. To perform the necessary actions and to understand the actions taken by the user, an intelligent device like a microcontroller, ATMega16L is used. ESP8266 offers a complete and self-contained Wi-Fi networking solution, which sends the samples of data wirelessly to the application on mobile. The application is developed having the same display as that of a DSO. The user will be able to observe the waveforms and also control them by buttons given on the screen. D0epending on the data samples the corresponding waveform is plotted on the GUI. This paper summarizes the implementation of a portable DSO module with a GUI using an Android application.**

Index Terms- **Android, DSO, ESP, GUI, WiFi.**

I. INTRODUCTION

A Digital Storage Oscilloscope (DSO) uses digital memory to store a waveform. In order to do this the incoming signal is first digitized, once this is complete the data in the memory can be continuously replayed through a Digital to Analogue (DAC) converter and displayed on a CRT. Unlike analogue storage scopes the captured waveform does not decay over time. The observed waveform can be analysed for properties such as amplitude, frequency, rise-time, time-interval, distortion and others. DSOs are often used to record complex waveforms such as video signals. This project gives basis to further studies and developments, given that several blocks were mathematically and experimentally validated.[1] [2].

Fig. No. 1 : Conventional DSO

II.PREVIOUS WORK

- The implementation of an oscilloscope with Bluetooth was previously reported by Yus [3] . It is an open source prototype project called the ―Android Bluetooth oscilloscope‖, which consisted of a Bluetooth enabled transmitter circuit to send data to an Android phone which draws the waveform on its screen. The transmitter circuit uses Microchip's dsPIC33FJ16GS504 and an LMX9838 Bluetooth 2.0 module. The maximum input voltage to this circuit is +8V to -8V. However, there is no mention about the bandwidth of the device. Furthermore, it is stated that the application had been tested only with Samsung GT-i5700(rooted Android 2.1 OS) phone. As the connection is Bluetooth interface it restricts the usability only to few metres. [3]
- A bachelor thesis was reported by [4] on Android based DSO. It was developed with an aim to create a fast and powerful open source

oscilloscope. It consisted of an application that requires rapid data acquisition, hardware development, micro controller firmware and an Android application. It uses the Universal Serial Bus (USB) interface, Complex Programming Logic Device (CPLD) firmware and system modeling. They have used the Beagleboard, Open Multimedia Applications Platform (OMAP) 3530 Advanced RISC Machine (ARM) platform as a basis for the Android OS.[4]

- Tektronix has launched 3 Android applications for use with oscilloscope – Tektronix Oscillo Connect, Tektronix Oscillo Analyzer, Tektronix Oscillo Triggevent.

Fig. No. 2 : Portable DSO

III. DESIGN METHODOLOGY

The block diagram of Android based DSO is given:

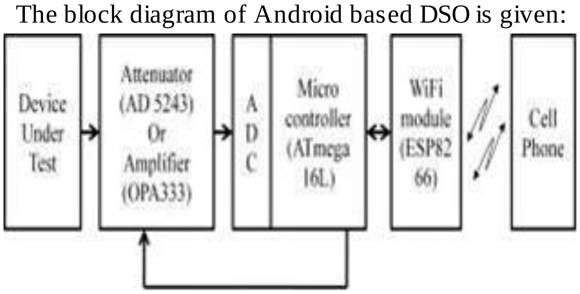

Fig. No. 3: Block Diagram of Android based DSO

- *Device Under Test:* Signals having frequency between 0-100Hz and amplitude 0-10V can be measured on Android based DSO. Examples of these signals are: Biometric signals, automotive signals ,spurious signals, interfering radio signals, low frequency clock signals, extremely low frequencies generated by lightening and natural disturbance in earth's magnetic field.
- *Attenuator:* Attenuator is used to bring down signal level within the desired range of amplitudes. If the amplitude is more than the desired range then attenuation is provided by resistors in voltage divider bias combination. The AD5243 is a 3-terminal mechanical potentiometer. The resistance between the terminals A & B can be adjusted by varying Voltage at point A (VA) and Voltage at point B (VB). Volt/div knob on DSO corresponds to the attenuation provided. When the Volts/div knob is varied on the mobile, the microcontroller will send corresponding signal to AD5243. According to the signal sent by the controller, the voltages VA will vary leading to change in the resistance. [5]
- *Amplifier:* If the signal voltage is too high, it would be attenuated or else it needs to be amplified in order to suffice the minimum need of the ADC.[5].
- *Microcontroller: To* change the attenuation/ amplification level the necessary actions to be taken and to understand the operations performed by the user, an intelligent device like a microcontroller is needed. Inbuilt ADC available in ATmega64L has a sampling rate of 15KSps. If Volt/div knob is varied on the GUI, this information is sent to microcontroller to set corresponding attenuation level. [5]
- *WiFi Module:* ESP8266 serves as a Wi-Fi adapter, wireless internet access can be added to any microcontroller-based design with simple connectivity through UART interface. ESP8266 on-board processing and storage capabilities allow it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. It requires minimal external circuitry, and the entire solution, including front-end module is designed to occupy minimal PCB area. It is interfaced to the microcontroller ATmega 16L using serial communication (RS232) which sends data wirelessly to the phone. [5].
- *GUI:* The display of the application developed is similar to that of a DSO. The user is able to observe the waveforms and also control them by buttons given on the screen. The display will have the following features : Volts/div knob which will correspond to the attenuation provided. Varying the time/div knob will lead to

change in the graphical representation of the waveform. In addition to this, cursors are used to measure various parameters.The min, max, and peak to peak values of the signal are directly displayed on the screen [5].

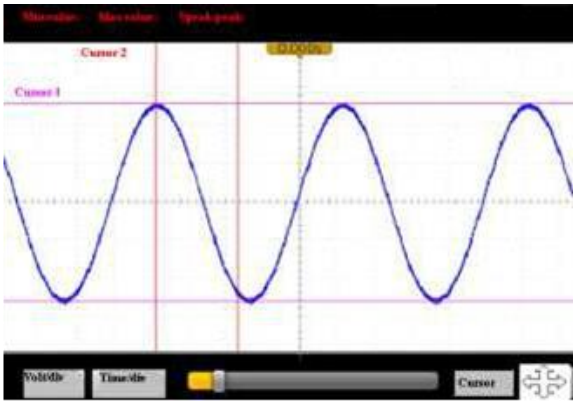

Fig. No. 4 : GUI

IV. IMPLEMENTATION DETAILS

- Testing the pre-processing circuit :

The pre-processing circuit consists of AD5243(as an attenuator or an amplifier), Low Pass Filter(LPF) with cut-off frequency 100Hz .

The circuit diagram is as follows :

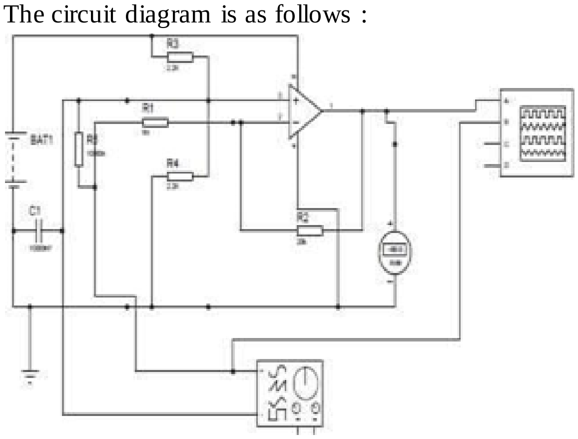

Fig. No. 5 : Pre-processing circuit

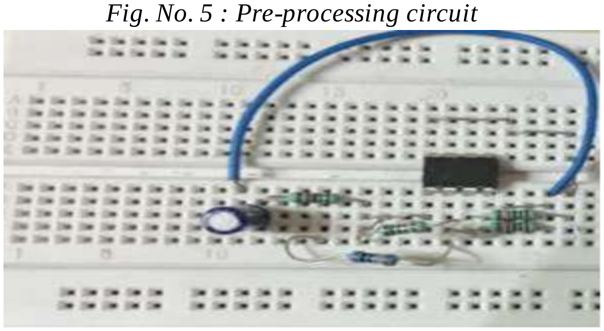

Fig. No. 6 : Breadboard implementation of pre-processing circuit

Following these steps the WiFi module was tested for it's correct functionality.

- Testing the WiFi Module :

  Initially, the ESP is configured. A socket is created at the client(mobile phone) and the server (ESP module).

  Hardcoded data is sent from the ESP module and received on the mobile phone and displayed on the'Socket Protocol' application.

  An LCD is interfaced to know the current status of the ESP module

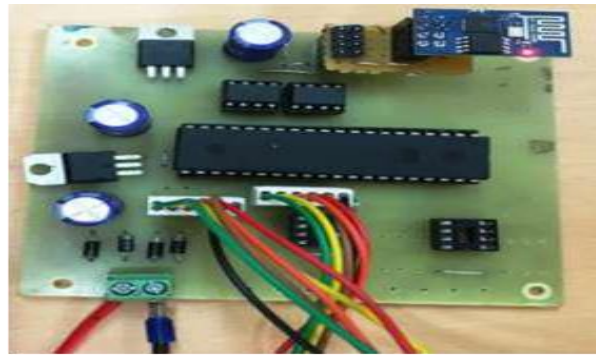

Fig. No. 7: Implementation of ESP module testing

- Displaying the waveform on the Android application:

  Random data is entered through a software 'Socket Test v3.0.0' the socket connection is established. This transmitted data was then received by the application and the data is plotted accordingly.

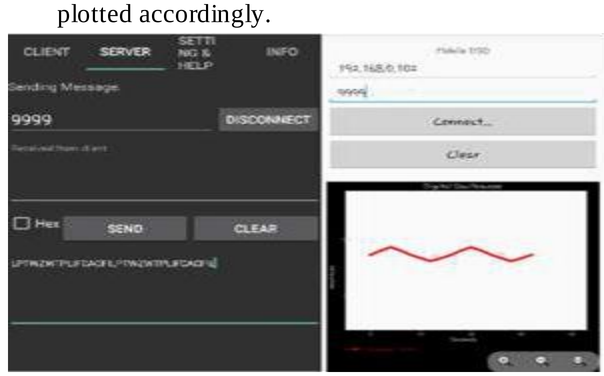

Fig. No. 8: GUI of the basic application developed

V. ALGORITHM

- Start
- Configure ESP module.
- Establish a connection between Wifi module and Android device.
- Capture the signal from device under test
- Attenuate the signal if necessary
- Vary the gain of the amplifier to amplify the signal if necessary.

- Analog to digital conversion using inbuilt ADC in ATmega16L.
- Store the samples in data memory of microcontroller.
- If the buffer is full send the samples to WiFi module.
- Store the received data from WiFi module on phone memory.
- Plot the waveform using the data stored in mobile.
- If Volt/div knob is varied on the GUI, send this information through ESP to microcontroller in order to set corresponding attenuation level.
- If Time/div knob is varied on the GUI, change the plot.

VI. ADVANTAGES AND LIMITATIONS OF ANDROID BASED DSO OVER EXISTING OSCILLOSCOPES

- Advantages:

  Android based DSO is a prototype developed for low amplitude and low frequency applications.

  The reliable operation of the system ensures no data loss i.e. entire data transfer to the end user. Such data integrity adds up to justify the usage of Android based DSO.

  The application is compatible with all Android platforms. It consumes low memory in the phone up to few hundreds of kB.
- Limitations:

  The developed system is very limited when compared to the features of conventional DSOs. However this project's main idea is to develop a low cost system to provide an initial basis for further studies and developments.

  Some considerations about the developed system are listed below:

➢ Improve the Android application interface.
➢ Develop an application for other platforms, like iOS.
➢ The battery could be replaced for another one with more capacity, increasing the life of the system.

VII. APPLICATIONS OF ANDROID BASED DSO

All signals with low amplitude and frequency can be viewed. Some examples are:-

- Biometric signals
- Automotive
- Testing and replacing antilock brake system components: Erratic frequency changes or unstable waveforms can be viewed on DSO. These signals would have damaged the trigger wheel and thus before applying them we can see them on the low frequency, low amplitude DSO.
- Detection of spurious signals interfering useful signals while receiving them inside a Radio receiver.
- Low frequency clock signals in switching elements can damage electric motors, wind shield wipers, servo-units, fuel supply pump, etc. Thus for their detection and analysis our DSO is used.
- Communication: ELF (Extremely low frequencies) are the frequencies for electromagnetic radiation (Radio waves) from 3 – 30 Hz. These are generated by lightning and natural disturbance in Earth's magnetic field. Thus Android based DSO can be used to observe these signals.

VIII. FUTURE SCOPE OF ANDROID BASED DSO

Few components can be replaced in the prototype with similar advanced components and can be used for high end applications. The existing circuit need not be altered to a great extent. More features in the GUI can be added such as:

- The 3 Trigger modes-Auto, Normal, Single.
- Coupling-AC, DC, GND.
- Hold Off button can be added.
- A multi-channel oscilloscope can be made.
- Level knob can be added.

Sampling rate can be increased in order to observe glitches, jitter in the signals. For faster data transfer, a Wi-Fi module with large baud rate can be selected. Using further enhancement FFT can be obtained.

Fig. No. 9: Testing of ESP module

IX. CONCLUSION

The developed system is capable of acquiring signals below100Hz, eg. Biometric signals. The traditional DSOs are very heavy and thus are inconvenient to carry. They are available at very high prices. Their usage is restricted to lab experiments. Android based DSO has been designed to overcome these drawbacks and to facilitate field work.

Taking into consideration the numerous benefits of Wi-Fi, it is used as a medium to transmit data to the mobile application. Android, being a current trend provides a method of developing powerful, attractive interfaces. Thus, the system final cost is reduced since the user may use its daily organizational mobile device as interface for analyzing waveforms.

A full duplex communication has been established between the hardware and the application. Therefore, the real time data is transmitted to the application and the actions taken by the user are reflected back into the hardware.

As this project uses cheap electronic components that are easily available online, it can help others to develop a more powerful prototype. By using high speed components and providing additional facilities in the application, the system can be put to use for high end applications.

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